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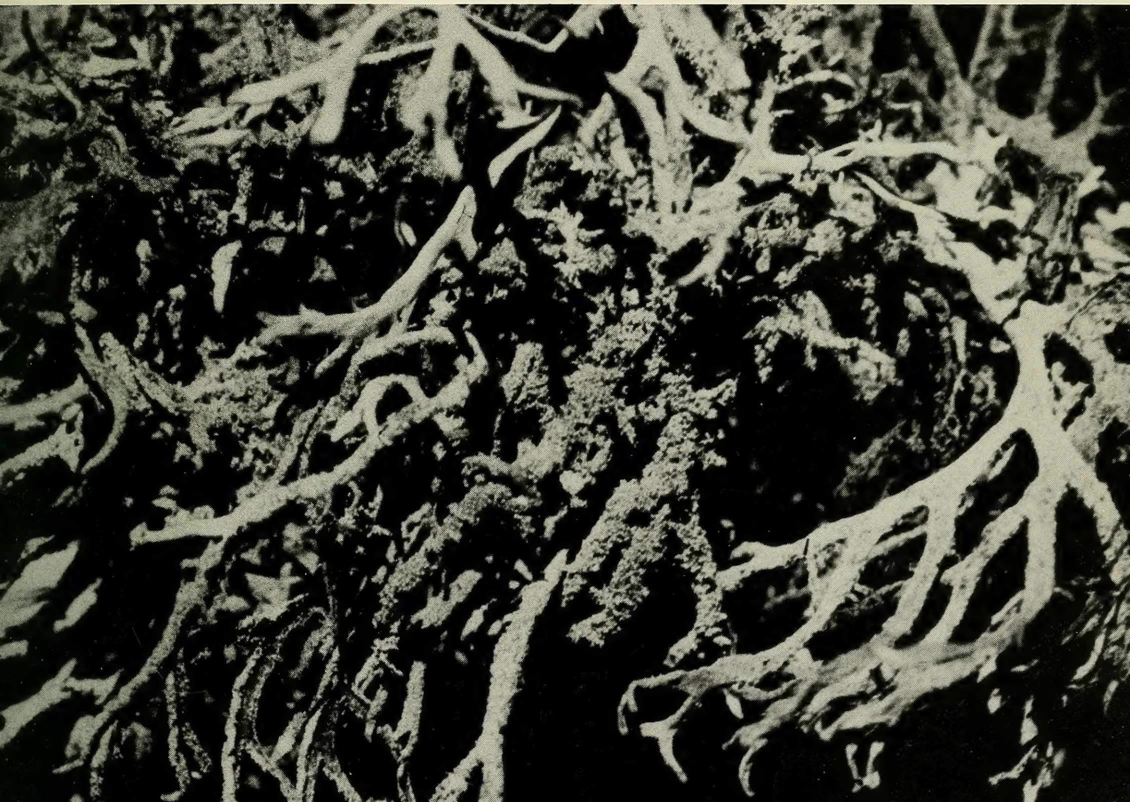

Volume 103, Number 1 **January-March 1989**

THE CANADIAN FIELD-NATURALIST

Volume 103

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THE OTTAWA FIELD-NATURALISTS' CLUB

OTTAWA CANADA

The Ottawa Field-Naturalists' Club

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Back Numbers and Index

Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club*, 1879-1886, and *The Ottawa Naturalist*, 1887-1919, and *Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist — Index* compiled by John M. Gillett, may be purchased from the Business Manager.

Cover: The lichen *Pseudevernia consocians* photographed at Bell Lake, Porcupine Provincial Forest, Manitoba by J. D. Johnston. *See:* Additions to the Lichen flora of Alberta and Manitoba, pp. 96-99.

The Canadian Field-Naturalist

Volume 103, Number 1 January-March 1989

Seasonal Movements and Winter Ecology of the Coyote, *Canis latrans*, in Northern New Brunswick

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Parker, G. R., and J. W. Maxwell. 1989. Seasonal movements and winter ecology of the Coyote, *Canis latrans*, in northern New Brunswick. Canadian Field-Naturalist 103(1): 1–11.

Changes in the seasonal ranges and the winter ecology of Coyotes (*Canis latrans*) were studied in a forested area of northern New Brunswick from May 1983 through June 1984. The size of an adult female's range varied from 9.5 km^2 when tending pups at the den site to 41.3 km^2 in winter. Inter-seasonal minimum daily cruising distances (MDCD) corresponded to inter-seasonal changes in range size. In winter, however, when range size remained stable from January through March, relative MDCD values increased from 3.8 km through 6.0 km. In winter, Coyotes travelled through mature conifer forest stands and along frozen streams and stream edges rather than through more open, mature, deciduous-dominated habitat. Coyotes preyed on Snowshoe Hares (*Lepus americanus*) in January and early February but switched to White-tailed Deer (*Odocoileus virginianus*) in mid-February and early March.

Key Words: Coyote, *Canis latrans*, New Brunswick, winter ecology, habitat use.

The Coyote, *Canis latrans*, has been studied extensively throughout most of its range in North America [for a review see Bekoff (1978b)] but still remains one of the most controversial predators. This is especially so along the northeastern limits of its range where the Coyote has only recently become established and its relationship with potential prey species and other predators remains virtually unknown (Hilton 1976; Major 1984; Moore and Millar 1984). Coyotes may have appeared in Maine as early as 1936 (Richens and Hugie 1974) and moved into New Brunswick by the 1950s, becoming common there by 1975 (Hilton 1978; Moore and Millar 1984). By the mid-1970s it had reached Nova Scotia, where it is now common, and the recent trapping of several Coyotes on Prince Edward Island (R. Dibblee, personal communication), indicates that Coyotes have now invaded that highly agricultural province. The ecological and economic impact of Coyotes varies with abundance and diversity of available prey, prevailing environmental (specifically winter weather) conditions, and consequent extent of human-Coyote interaction.

This paper reports on a study of Coyotes in a non-agricultural wooded area of northern New Brunswick. This study of Coyotes represented part of a more comprehensive study on the impact of intensive forest management upon bird and mammal communities.

Study Area and Methods

The 130-km^2 study area, located in the northern region of New Brunswick (47°30′N, 67°30′W), is part of a large tract of land managed for the production of wood products. Most of the mature stands of spruce, *Picea* spp., and Balsam Fir, *Abies balsamea*, have been clear-cut in the past 15-20 years and the land is now a mosaic of various-aged clearcuts and conifer plantations. Mature deciduous stands remain on the upper slopes and hill tops, whereas a mixture of subcommercial spruce, cedar and alder swales is common along the stream and river valleys. Thus the study area comprises a wide diversity and juxtaposition of habitat types.

The region has been classified as the Temiscouata-Restigouche Section of the Great Lakes-St. Lawrence Forest Region by Rowe (1972). Dominant deciduous tree species on the hills and slopes are Beech, *Fagus grandifolia*, Sugar Maple, *Acer saccharum*, and Yellow Birch, *Betula alleghaniensis*, and mature spruce and Balsam Fir are common in the valleys. Eastern Cedar, *Thuja occidentalis*, is a common component of riparian and poorly drained sites.

The climate is more continental than maritime and summers are normally hot with moderate rainfall. The winters are characterized by low temperatures with snow accumulation $\geq$ 1 m deep being common from January through March.

Coyotes were captured in number 3 Victor coilspring, padded leghold traps, immobilized with ketamine hydrochloride (concentration 100 mg/ml; 15.0 mg/kg body weight; available from Rogar/STB, London, Ontario) fitted with a 151 MHz transmitter collar, and released. A Telonics Model TR-2 series telemetry receiver and hand-held antennae were used for relocations.

Seasonal range limits were documented for an adult female Coyote and her pups by radio-telemetry. Three other Coyotes were collared with radio transmitters but information on range sizes proved discontinuous and inconclusive. One juvenile female left the study area shortly after being trapped on 7 October and was killed on the highway near Juniper approximately two months later (exact date uncertain) 80 km south of the point of capture. The radio transmitter of a second juvenile female malfunctioned shortly after release, and an adult female moved out of the study area to where only occasional monitoring was possible.

Travel for radiotracking was facilitated by truck and trail bike in summer and by snowmobile and snowshoe in winter. As collared Coyotes were near roads at most times, close approach and accurate locations (± 50 m) were often possible. At other times, standard methods of triangulation were used.

Seasonal range limits were established using the modified minimum area method (Harvey and Barbour 1965). Calculated ranges used only the first established location each day, normally between 0700 h and 1000 h. Thus the calculated ranges, based upon single daily locations, must be considered minimal and do not include peripheral areas which additional but discontinuous telemetry data suggested Coyotes often used during crepuscular and nocturnal hunting forays.

Straight-line distances were measured between the first locations on consecutive days. The average of those measurements provided the minimum daily cruising distance (MDCD); this shows the distance between consecutive daily resting locations.

A winter camp was occupied by field staff from January through March 1984. Data on winter activities of Coyotes were collected by following Coyote trails on snowshoes. A record was maintained of distance travelled on each Coyote trail by converting total snowshoe steps to metres. Cover-typing of the study area into specific habitats allowed designation of distance of trail among habitat types.

Coyote activities and sign observed during snowtracking (beds, chases, kills) were recorded by habitat type following the method described by Parker et al. (1983) for winter studies of Lynx, *Lynx canadensis*.

Chi-square goodness-of-fit tests were used to test for habitat selection by distance of trail and activities. White-tailed Deer, *Odocoileus virginianus*, carcasses were found while trailing Coyotes in snow as well as by chance when travelling in the study area by snowmobile. Although deer were common throughout the study area during the snow-free period, they were concentrated into two distinct deer yards during the winter of 1983-84. Deer killed by Coyotes were aged by standard tooth eruption and wear patterns (Larson and Taber 1980), and physical condition was appraised by the percentage of fat in a sample of femur marrow as determined by the dry weight method (Neiland 1970).

Results

Seasonal ranges

For the purpose of illustrating changes in the intensity of seasonal range use, the period of observation was divided into the following periods: 1) spring (May-June) — associated with denning and restricted movement by pups; 2) summer (July-August) — greater pup mobility and abundant food sources; 3) autumn (September-October) — onset of cool weather, greater pup independence and mobility; and 4) winter (January-March) — continuous snow cover. Due to unfavourable travel conditions in spring and early winter, no attempts were made to obtain radio locations in the months of November, December, or April.

One or more locations of the female Coyote with pups was obtained on 123 days (39% of total possible days) from May 1983 through March 1984, and a further 20 daily locations were recorded during the period May-June 1984 (33% of total possible days).

Spring 1983. — The adult female was lactating when captured on 22 May 1983 and likely had a litter of pups approximately 30 days old. (On 24 May 1984 the litter of a second radio-collared female Coyote was found and, based upon body development and mobility (Bekoff 1978a), the pups were estimated to have been approximately 4-5 weeks old.) During the 24 h following release, the female moved approximately 5.5 km from the capture site. She then moved back into a confined range where movement became limited and predictable through the remainder of May and June (Figure 1a). During this denning season the calculated range reached a minimum value of 9.5 km^2 (n = 34).

Summer 1983. — During the pup-rearing season, minimum range expanded to 21.7 km^2

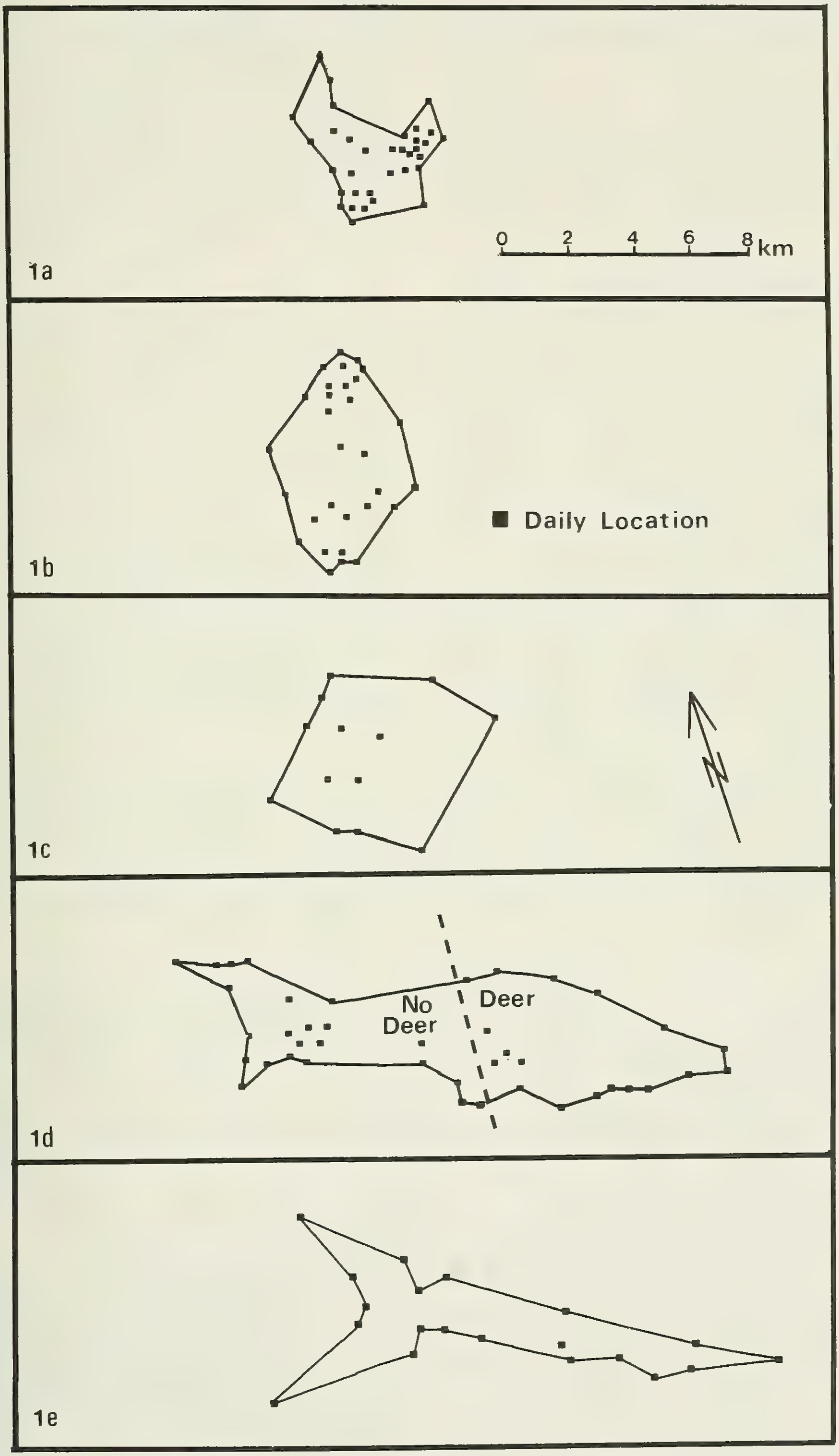

FIGURE 1. The estimated minimum seasonal range limits of a radio-collared adult female Coyote in northern New Brunswick: (a) spring 1983 (b) summer 1983 (c) autumn 1983 (d) winter 1983–84 (e) spring 1984.

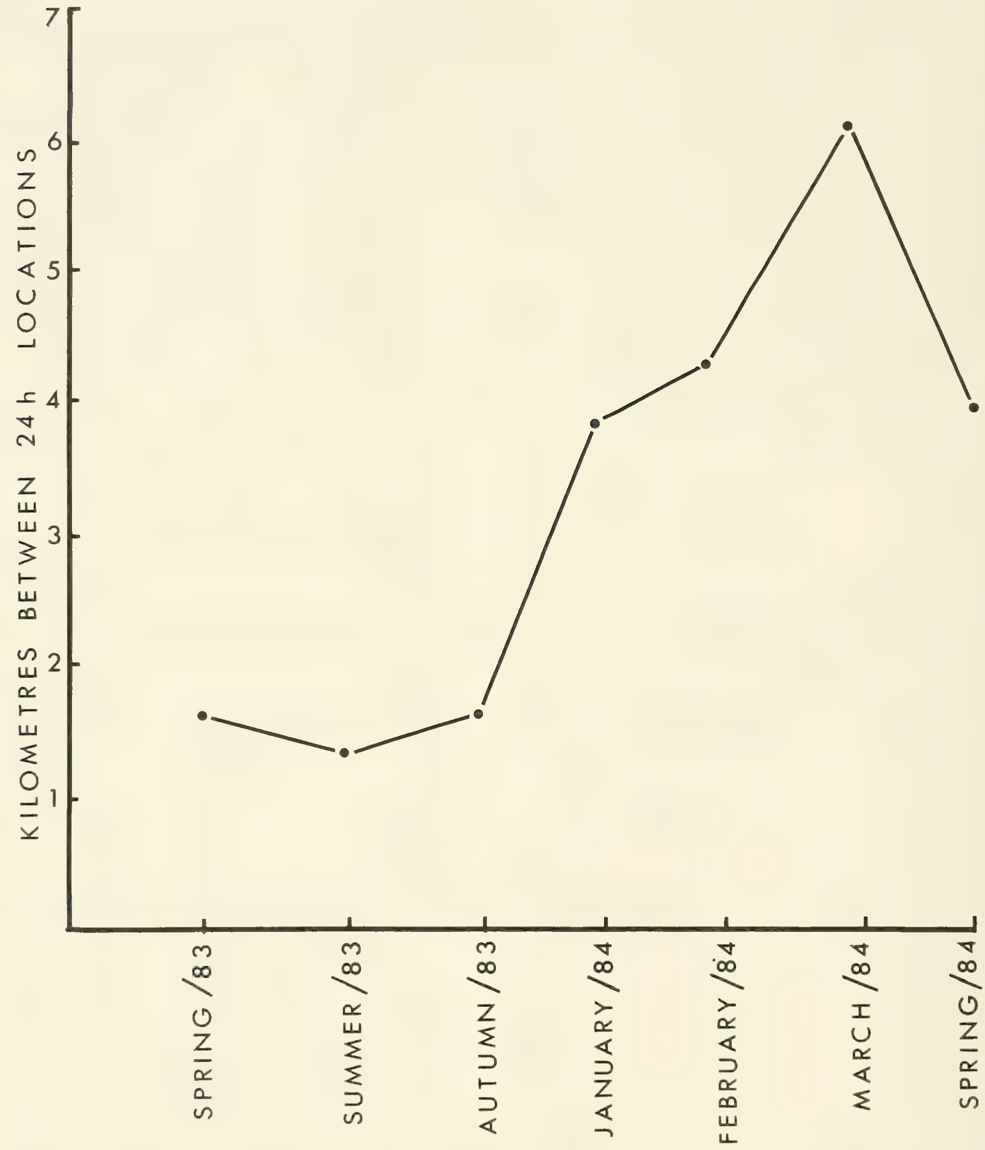

FIGURE 2. Seasonal changes in minimum daily cruising distances (MDCD) for an adult female Coyote in northern New Brunswick.

(n = 31) (Figure 1b). It was characterized by two centres of activity, each located in separate river valleys approximately 4 km apart. The female and pups travelled from one site to the other with little time spent in between. The pups were now howling regularly in the evenings.

Autumn 1983. — The home range (25.0 km²) of the female during this period was based on the fewest observations (n = 13) and range limits must be considered least precise (Figure 1c). Range limits differed little from the summer period although daily locations were more scattered than in summer.

Winter 1983-84. — Range size increased to 41.3 km² (n = 32). By month, range size estimates were January, 44.2 km² (n = 10), February, 41.0 km² (n = 13), March, 39.6 km² (n = 9). The increase in area between autumn and winter resulted from an eastward extension of the group although most activity was restricted to one river valley and adjacent slopes (Figure 1d). During this three-month winter period, the adult female travelled exclusively with two pups in January, occasionally left them for one- to two-day periods in February and travelled more frequently alone in March. The female occasionally travelled with an adult male in February and sign indicated frequent copulation.

Spring 1984. — Locations during the second spring suggest that the female did not successfully whelp in 1984. There were no centres of activity suggesting den sites, and the calculated range (24.6 km^2; n = 20) was much larger than in spring 1983 (Figure 1e).

Minimum daily cruising distances (MDCD)

One hundred and twenty-seven pairs of consecutive daily radio locations of the adult female monitored through 14 months were used to calculate seasonal minimum daily cruising distances (MDCD). The MDCD was lowest in spring and summer when the female tended denning sites (1983), peaked in winter when the female and pups travelled extensively, and declined to an intermediate value during the following spring (1984) when she did not have pups (Figure 2).

Range size decreased slightly between January and February (–7.2%) and between February and March (–3.4%); the respective changes in estimated MDCD values were + 10.2% and + 43.1%.

Winter habitat use

Two hundred and sixty-three kilometres (170 mi) of Coyote trail were followed by snowshoe from January through March 1984. The proportions of that sample by month were January — 42.3%; February — 32.3%; March — 25.4%. Most of the tracking was of two radio-collared females and accompanying Coyotes. The proportions of total trails followed made by single or groups of two and three Coyotes were 24%, 21% and 55%, respectively.

Coyote trails were subsequently allocated to 15 major habitat types (Table 1). Coyotes often used snow-covered roads for travel. Although roads and trails comprised less than 2% of the study area, that habitat type contained 39% of the trails followed.

To assess use of the other habitats, roads and trails were eliminated (due to small sample sizes, the open field habitat also was eliminated and stream edge and stream ice combined into a single type). Because of the well-delineated winter range of the adult female and two pups, only the sample of trails within that home range (80% of trails followed) was used to ensure a more accurate assessment of actual habitat selection. Thus, the total sample of trails used in assessing habitat use was reduced to 112 km within 11 habitat types. The expected kilometres of trail within each habitat was the product of distance of trails followed (112 km) and the proportion of each habitat type within the home range of the adult female (measured with dot grid on 1:12 500 colour aerial photographs). A Chi-square test for goodness-of-fit indicated significant ($P < 0.05$) selection for mature conifer, frozen streams and stream edges and natural regeneration 11-20 years of age and significant selection against mature mixed and deciduous forest stands (Figure 3). The remaining habitat types were used relative to their availability.

TABLE 1. Distribution of 263 km of Coyote trail among 15 habitat types based on snow-tracking studies in northern New Brunswick during January-March 1984.

	Km of trail followed			
Habitat type	January	February	March	Total
Mature conifer	14.3	18.2	14.7	47.2
Mature mixed	2.0	3.2	2.6	7.8
Mature hardwood	3.5	4.1	2.4	10.0
Road	51.4	27.0	14.5	92.9
Trail	2.7	1.2	6.2	10.1
Open field	1.0	0.6	1.6	3.2
Plantation ≤ 4 years	10.2	3.2	3.8	17.2
Plantation 5-8 years	6.7	2.4	1.8	10.9
Plantation > 8 years	9.0	13.8	10.2	33.0
Natural regeneration 5-10 years	1.8	1.1	0.2	3.1
Natural regeneration 11-20 years	0.5	5.8	1.4	7.7
Natural regeneration 21-40 years	1.8	2.2	5.2	9.2
River ice	0.2	0.7	0.9	1.8
Stream bank	1.6	0.9	2.0	4.5
Alder swale	0.5	1.4	3.3	5.2
Total	107.2	85.8	70.8	263.8

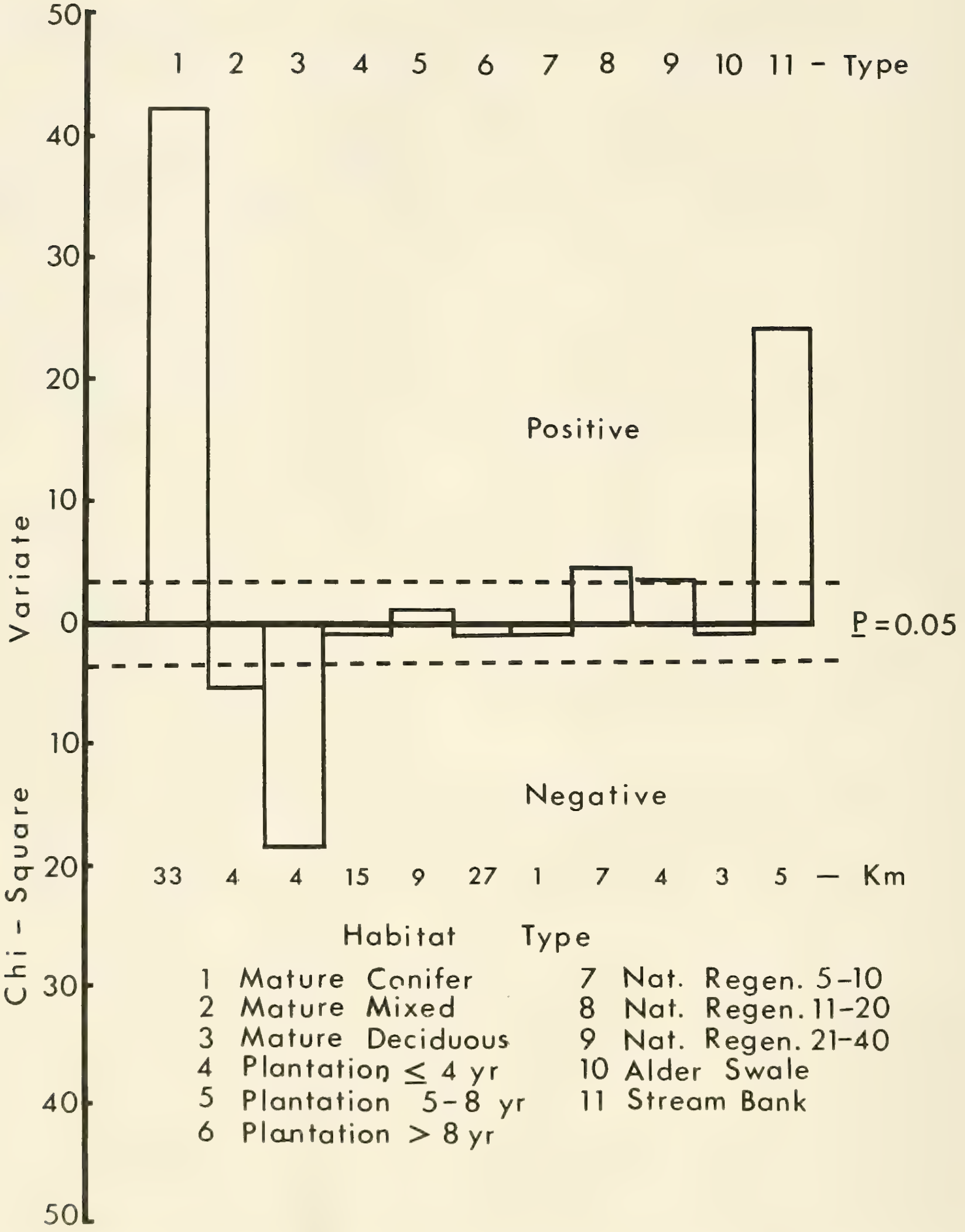

FIGURE 3. Relative habitat selection by an adult female Coyote and two pups within a 41.3 km^2 winter range in northern New Brunswick, during January through March 1984.

Prey selection

The main foods of Coyotes during winter were Snowshoe Hares, *Lepus americanus*, and White-tailed Deer (Table 2). In early winter when snow was deep ($\geq$ 1 m) and light, Coyotes preyed nearly exclusively on hares supplemented with small mammals (eg. *Clethrionomys gapperi*) and deer and Moose, *Alces alces*, remains dug from beneath the snow. The deer and Moose were believed to have been left from the autumn public hunting season.

TABLE 2. Frequency of deer and hares killed by Coyotes from January through March 1984, in a wilderness study area in northern New Brunswick.

			Kills			
			White-tailed Deer		Snowshoe Hare	
Month	Km of trail	MDCD[1]	n	deer/km (x100)	n	hares/km (x100)
January	106	3.83	0	0.0	13	12.1
February	86	4.23	3	3.5	6	7.0
March	71	6.05	7	9.9	4	5.6
Totals	263		10	3.8	23	8.7

[1]estimated minimum daily cruising distance (km).

At this time Coyotes were sinking 14-20 cm in snow in most open woodlands but only 6-8 cm in closed conifer woodlands. In recent clearcuts and young plantations exposed to the winds, Coyotes often walked on top of the hardened surface. By late February, except during brief periods after fresh snowfalls, Coyotes rarely sank over 8-10 cm in any habitat.

The observed hunting success (% successful chases) of Coyotes upon Snowshoe Hares was high. Hunting success values for January, February, and March were 100%, 60%, and 100%, respectively, for an overall total of 85% (23 kills in 27 chases). Chases seldom consisted of more than several jumps and often no chase was evident at all. Consumption of hares was usually total with only traces of fur and offal remaining. The frequency of hares killed with distance travelled declined through the winter (Table 2). However, as MDCD increased from 3.8 km in January to 6.0 km in March, the actual rate of predation declined only slightly from an estimated 1 hare per group per 2.1 days in January to 1 hare per group per 2.9 days in March.

The decline in predation rate upon hares from January to March was not due to a decline in hunting success, but rather to the Coyotes' shift in prey selection from hares to White-tailed Deer. Whereas the frequency of hares killed with distance travelled declined from January through March, that for deer increased (Table 2). The increase in rate of predation upon deer through the winter was pronounced, from none killed (or chased) in 106 km of trail in January to seven killed in 71 km of trail in March.

The estimated predation rate on deer by groups of three Coyotes (two such groups in sample) increased from none in January to one per 6.8 days in February to one per 1.7 days in March. On an individual basis the predation rates for February and March would have been one deer per 20.4 days and 5.1 days, respectively. These predation rates are based on snow tracking of two groups of three Coyotes: a radio-collared female with two pups and a radio-collared adult female and two adults of unknown sex. Our findings indicate that no deer were killed by groups smaller than three Coyotes.

The movement patterns of the female and two pups through the entire winter, and the associated distribution of hare and deer kills indicate a seasonal switch from hares to deer (Figure 4). From the sample of trails followed between telemetry locations, the female and two pups killed 11 hares and one deer from 10 January to 3 February (24 days: 1 hare per 2.2 days; 1 deer per 24 days). From 11 February to 6 March this same group of Coyotes killed five deer and four hares (23 days: 1 hare per 5.7 days; 1 deer per 4.6 days).

As the deer were yarded within a mature conifer-dominated forest stand, nine of ten deer killed by Coyotes were within that habitat type. The remaining kill was in a 21- to 40-year-old, naturally regenerating, mixed forest stand. The 23 hare kills were much more evenly distributed among available habitat types.

Deer kills — age, condition

Seventeen deer killed by Coyotes were found during the winter. The age structure of that sample was fawns (< 12 months) = 12 (70.6%); yearlings (> 12 months < 24 months) = 2 (11.8%); 2-year-olds (> 24 months < 36 months) = 2 (11.8%), and adults (> 36 months) = 1 (5.8%). The percentage of fat in a sample of femur marrow of deer is considered an index of physical condition (Ransom 1965). The percentage of fat in marrow by age classes were fawns = 56.9%; yearlings = 63.0%; 2-year-olds = 71.5%; adults = 92.0%.

Distribution of Coyote beds

Radio telemetry showed that Coyotes normally rested from mid-morning to late afternoon. One hundred and fifty-one Coyote beds were recorded in 263 km of Coyote trail (one bed per 1.74 km). As many Coyote trails were made by more than one Coyote and beds were often in groups, the actual frequency of beds per distance per Coyote would probably be in the range of one per 2-3 km of trail.

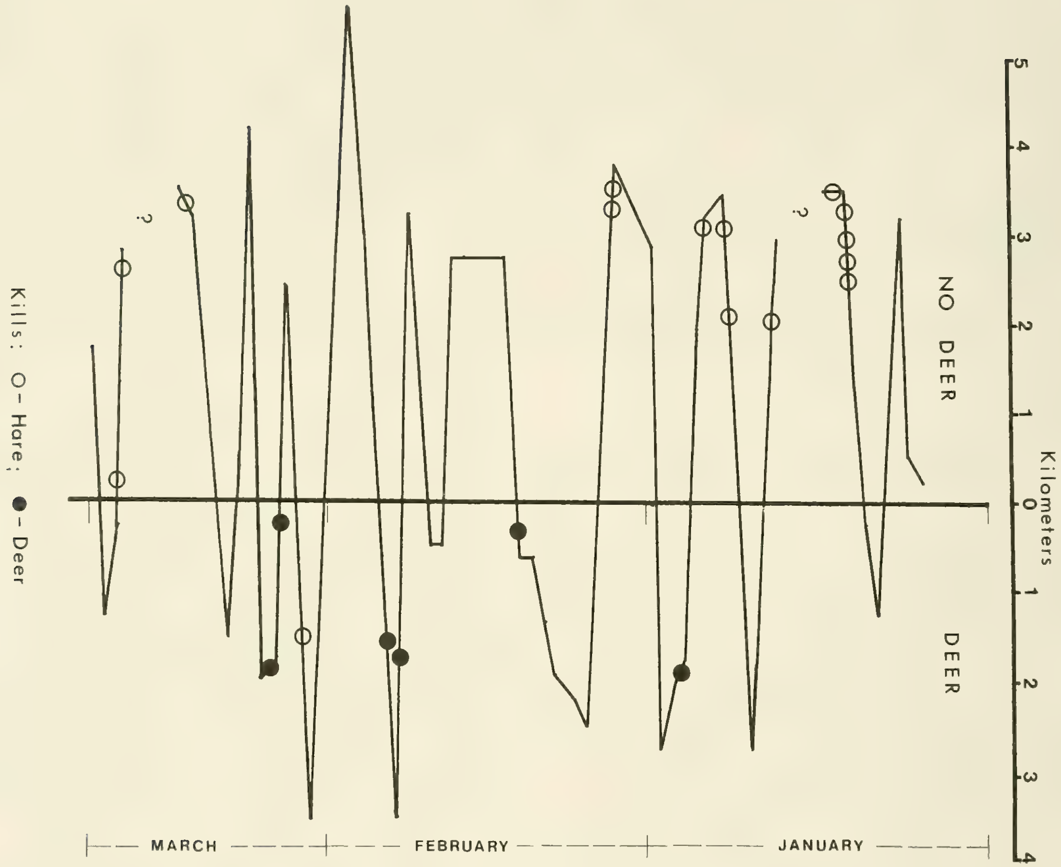

FIGURE 4. The movement patterns of an adult female Coyote and two pups relative to a winter deer yard and the distribution of documented hare and deer kills determined from snow-tracking.

As with the distribution of kills and kilometers of trail, selection of habitat type for beds was tested by the Chi-square goodness-of-fit test. Only those cells (habitat types) with five beds or more were used in the analysis; plantations > 8 years of age were tested as a single cell to increase sample size (Table 3). The sample was thus reduced to 142. The overall distribution of beds showed significant habitat selection by Coyotes for resting ($P < 0.02$), but by individual habitat type, Coyotes selected only for the mature mixed type ($\chi^2 = 7.11$; *d.f.* = 1; $P < 0.01$) and against the 5 to 20 year old natural regeneration type ($\chi^2 = 4.08$; *d.f.* = 1; $P < 0.05$).

The mature mixed forest provided numerous protected but open and sunny locations for beds. Even in the highly used mature conifer and older plantations, bedsites were often on a slightly raised or sloping hummock with southern exposure. The location of beds also suggested a selection for sites from which Coyotes could observe the immediate area.

Discussion

Many studies have documented the seasonal and annual home range sizes of Coyotes in North America (e.g. Stebler 1951; Gipson and Stealander 1972; Preece 1978; Berg and Chesness 1978; Major 1984; and others). Earlier estimates of home range sizes were developed through mark-recapture information (Murie 1940; Robinson and Cummings 1951). More recent studies have relied on snow tracking (Ozoga 1963; Ozoga and Harger 1966), radio telemetry (Huegel 1979; Preece 1978; Woodruff and Keller 1982; Messier and Barrette 1982; and others) and a combination of the two (Gipson and Sealander 1972).

Unfortunately, the different methods of data collection and subsequent disparate approaches to data interpretation and home range calculation serve more to confuse than clarify the issue. Add to this the spatial and temporal variations in seasonal and annual range use, complicated further by sex- and age-specific behavioural patterns, and comparisons of home range sizes among studies becomes hazardous (Laundre and Keller 1984).

TABLE 3. Observed (O) and expected (E) distribution of Coyote beds among dominant habitat types on study area in northern New Brunswick during winter 1983–84.

	Coyote trails followed		Beds		
Habitat type	Kilometres	%	O	E	χ^2
Mature conifer	47.2	36.6	47	52	0.05
Mature mixed	7.8	6.1	17	9	7.11*
Mature deciduous	10.0	7.8	8	11	0.81
Plantations 5-8 years	10.9	8.5	9	12	0.75
Plantations > 8 years	33.0	25.6	46	36	2.77
Natural regeneration:					
5-20 years	10.8	8.4	5	12	4.08**
21-40 years	9.2	7.0	10	10	0.00
Totals	128.9	100.0	142	142	15.57***

*selection for: d.f. = 1; $P < 0.01$
**selection against: d.f. = 1; $P < 0.05$
***d.f. = 6; $P < 0.02$

In this 14-month study, a general pattern of temporal changes in occupied range by the adult female was apparent. The female with young at the den site had the smallest range, her range expanded as the mobility of pups increased, and reached its maximum in autumn and during breeding activity in late winter. Although comparative seasonal range-size values are dissimilar, Preece (1978) found that denning ranges for adult female Coyotes in Minnesota were approximately 22% of the size of annual home ranges; comparable data for the radio-collared female with pups in this study was 23%. Differences in range size between the two denning seasons are likely due to the influence of raising pups one year and not the next.

Although direct comparisons of home range values are hazardous, winter (pre-denning) range values for adult Coyotes in northern forested habitat often approach 40-50 km^2 (Stebler 1951; Ozoga and Harger 1966; Major 1984; this study). In this study, MDCD values are used as comparative indices of seasonal changes in Coyote activity patterns and not as an actual measure of distance travelled in 24-h periods. Although estimates of seasonal range size and MDCD show a similar trend, the MDCD is considered more indicative of temporal changes in Coyote mobility.

Preece (1978) measured MDCD in a similar fashion for Coyotes in Minnesota allowing a comparison with data from New Brunswick. Pre-denning (winter), denning and post-denning MDCD values in Minnesota were 2.0, 1.3, and 2.2 km, respectively; in New Brunswick respective values were 4.6, 1.5, and 1.3 km. Pre-denning disparity in MDCD values between studies (2.1 times greater in New Brunswick) is consistent with larger pre-denning ranges in New Brunswick (1.3 times greater).

The seasonal changes in MDCD values for the adult female in northern New Brunswick can be explained by maternal responsibilities, breeding, prey distribution and winter snow conditions. Daily activity focused on the den site in spring 1983, increased in autumn and early winter with increasing pup mobility and peaked in late winter in response to breeding activity, improved travel conditions on compacted snow, and frequent travel into a deer yard. The adult female and pups were travelling more as winter progressed within a relatively stable winter range. MDCD decreased to intermediate values in spring 1984 when the female failed to whelp and was not restricted by maternal responsibilities.

Coyotes in northern New Brunswick preferred mature conifer habitat during winter. The ground is normally covered with snow from December through March, and snow accumulations by January often reach 1 m or more. Energy expenditure must be minimized during this period of restricted mobility and decreased prey availability. Mature conifer habitat provides minimal snow depths and optimal travel conditions. Snow cover in early winter has little weight-supporting capacity, and Coyotes, not adapted for survival in northern deep snow conditions (low weight-bearing capacity), select those habitats which provide minimum snow depths. Preference for frozen streams and stream banks (and snowmobile trails) can also be explained by similar reasoning. The deep soft snow and lack of prey availability in open, mature, mixed and deciduous forest habitat explains selection against those types.

A Chi-square goodness-of-fit test showed that, relative to the distribution of trails among types, Coyotes killed significantly more hares than expected ($\chi^2 = 6.40$; n = 5, $P < 0.05$) only in plantations > 5 years of age. As hares were most abundant during winter in older conifer plantations (Parker 1984), an increase in the frequency of hares killed by Coyotes in that habitat type is not unexpected (more Coyote-hare encounters). The selection for conifer-dominated habitat by Coyotes in northern New Brunswick is similar to that for Coyotes in Wisconsin (Huegel 1979) and Maine (Major 1984).

The importance of Snowshoe hare and White-tailed Deer to Coyotes in northern New Brunswick, especially during winter, has been documented from scat (Parker 1986) and stomach (Moore and Millar 1986) analyses. The frequency of kills found during winter snow tracking in this study confirms that dependence. The exclusiveness of diet between early (hare) and late winter (deer) is not unique to this study. The switching from hare to deer in late winter has also been reported in Maine (Dibello 1984; Miller 1984), Wisconsin (Huegel 1979) and Alberta (Bowen 1981).

Most studies relate increased predation on deer to increased winter severity and difficulty in killing hares. In our study area, however, predation on deer increased relative to increased mobility (increased MDCD); that increase is thought to have been a function of the onset of breeding activity and greater supporting capacity of the snow.

The deer yard represented approximately one-third the winter range of the adult female and her two pups and consisted of a mature conifer and mixed forest on a south-facing slope and an adjacent spruce-cedar stream valley. Mobility of the Coyotes was not hindered by snow condition in mid- and late February when predation upon deer began. In fact, the maximum home range axis was recorded in late February shortly after two deer were killed on consecutive nights.

Although Coyotes travelled over range in February where hares had been killed seemingly at will in January, and MDCD values were actually greater in February, no kills of hares were found during snow tracking. Observations of hares and tracks, however, suggested that availability of hares had changed little. Although 11 hares were found killed by the three Coyotes between 12 January and 3 February (22 days; 92 km of trail), no hares were found killed during tracking from 4 February through 1 March (25 days; 41 km of trail). Coyotes appeared to switch back to hares by mid-March. We suggest that prey switching by Coyotes in late winter may be as much a function of increased breeding-related travel and increased sociality of Coyotes (a consideration alluded to by Huegel (1979) in Wisconsin) and subsequent greater deer-Coyote interactions as a function of increased winter severity. Our observations during snow tracking also suggested that Coyotes often encountered deer more by coincidence than by design and chases were often short or non-existent. Most carcasses were fawns and most appeared to have been brought down from the side or rear. We believe that several died while being eviscerated. The chronology of carcass use by Coyotes as described by Huegel (1979) for White-tailed Deer killed in Wisconsin is similar to the chronology of use for most carcasses examined in this study.

The physical condition of Coyote-killed deer was excellent, indicating (as tracking observations suggested) that predation on deer resulted from chance encounters and attacks were spontaneous responses to visual stimuli. Our data do not support the hypothesis that Coyote predation on deer is insignificant and that those deer succumbing to predation would likely have died from other mortality factors (compensatory mortality) as suggested by Huegel (1979). The high incidence of fawns in the sample suggests that size and behaviour (slower reactions) of prey may also elicit an attack response.

Messier and Barrette (1985) commented on the apparent antipredator strategy of White-tailed Deer by yarding. They postulated that yarding and associated runways enhanced escape by deer and reduced Coyote:deer ratios. Our data support their observations that territorial behaviour of Coyotes discourages this predator from concentrating in deer yards. However, until differences in yarding behaviour by deer between Coyote and Coyote-free environments can be correlated to the presence and absence of that predator, we suggest that reduced predation as a consequence of yarding is coincidental to the primary strategy of energy conservation.

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Food Habits of Great Horned Owls, *Bubo virginianus*, in the Northern Taiga of the Yukon Territory and Alaska

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Weir, Douglas, and Ann Hanson. 1989. Food habits of Great Horned Owls, *Bubo virginianus*, in the northern taiga of the Yukon Territory and Alaska. Canadian Field-Naturalist 103(1): 12–17.

Prey in pellets at four Great Horned Owl (*Bubo virginianus*) nests in the Yukon Territory and Alaska was compared with bird and mammal communities. Snowshoe Hares (*Lepus americanus*) were the main prey. Owls took birds > 63 g and microtines > 31 g more often than expected and shrews and small birds less often. Two common squirrels were not taken.

Key Words: Great Horned Owls, *Bubo virginianus*, Yukon, Alaska, taiga, food habits.

Great Horned Owl, *Bubo virginianus*, food habits have been studied from Chile to Alberta (McInvaille and Keith 1974; Jaksic and Marti 1984). Comparable studies from the taiga, i.e. boreal conifer forest, are lacking. We collected pellets from a nest in western Alaska and three in the central Yukon Territory, and compared contents with censuses and other indications of the abundance of smaller mammals and of birds in the same areas.

We explored how well our limited data agreed with studies of *Bubo* elsewhere; a widespread, common pattern in food habits was demonstrated by Jaksic and Marti (1984). Food habits were studied near Rochester, Alberta, where many mammal and bird species were the same as, or similar to, those in our areas (McInvaille and Keith 1974).

The North American taiga shows marked north-south differences in vegetation and bird and mammal communities (Viereck 1975; Krebs and Wingate 1976; Spindler and Kessel 1980). The bird and mammal communities of our Yukon area were northern and it was north of the effective limits of *Pinus* and *Abies* (Oswald and Senyk 1977; Petersen et al., *in press*). Our Alaskan area was evidently northern, at the coastward limit of the taiga.

Study Areas

The two areas were near Dawson, Yukon Territory, and Bethel, Alaska (Figure 1). Yukon Territory nests were in the Klondike River and Indian River catchments, where taiga was more-or-less continuous before the Gold Rush. Mining altered valley floors to mosaics of broad-leaved trees and shrubs, bare ground and water. Associated logging depleted or cleared hillside taiga, which now is mostly at early stages of succession (Weir, *unpublished*).

The Alaskan nest was on the montane, upper Tuluksak River, where alpine tundra was the main vegetation, with woods confined to valley floors and lower hillsides. Mining had altered the main valleys much as in the Yukon Territory area, but small valleys and hillsides were much less affected (Weir, *unpublished*).

Methods

Owl Diet

DW collected 10-50 recent pellets at each of four successful nests in abandoned gold dredges, the Alaskan set T on 20 July 1974, Yukon Territory set A on 10 June 1980, and sets B and C there on 15 August 1980. AH analysed sets A to C and a worker at the American Museum of Natural History, New York, New York, analysed set T. The numbers of individuals in each pellet or batch of debris in sets A to C were determined from numbers of the same bones in each, usually skull parts. The numbers of similarly determined individuals were given for the entire set T, but species of birds and fishes, and the proportion of hares which were juveniles, were not given. Species identification details are in Table 1.

We assumed that smaller items were represented in only one pellet in all sets, but items > 300 g are normally represented in two or more (Reed and Reed 1928; Howard 1958). In sets A to C, minimum totals were determined for most prey species, which were < 200 g, and for large birds. The problem was with the staple Snowshoe Hare, *Lepus americanus*; 62 pellets contained hare remains, but only 17 (27%) contained skull parts. AH estimated the average weight of hares taken based on a dentary length-body length-weight relationship from 12 dentaires (*cf.* Morris 1979). The estimate was 400 g but was applicable to sets B and C, which contained mainly juveniles; set A contained only adults. For each set, we multiplied the number of hare occurrences by 300 (the weight of hare presumed to be represented in a pellet) and divided the product by the appropriate average

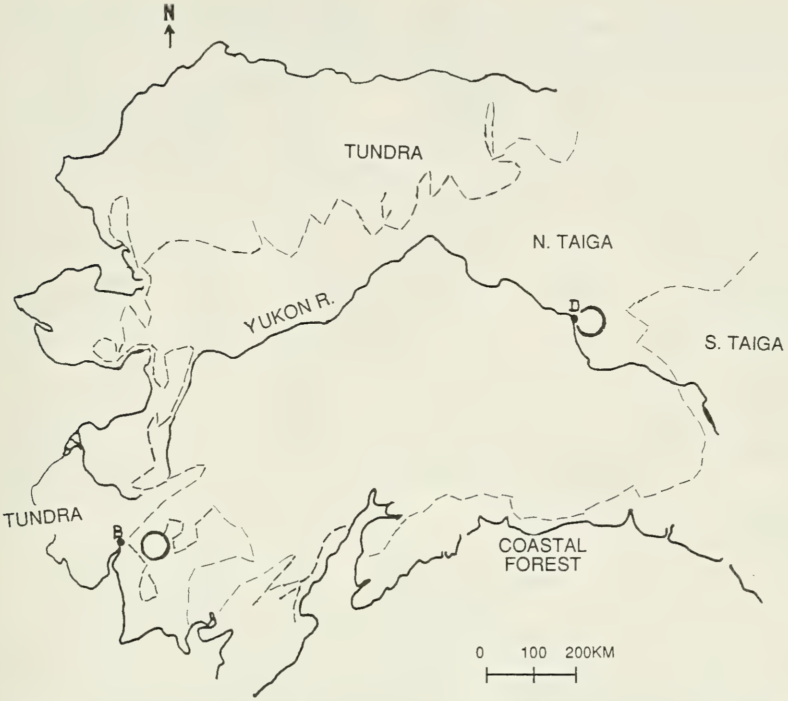

FIGURE 1. Locations of Great Horned Owl food study areas, near Dawson, Yukon Territory (64° N, 139° W) and Bethel, Alaska (61° N, 160° W). Key; B — Bethel, D — Dawson, open circles — study areas, dashed line — outer limits of our definition of northern taiga; much of the area is above treeline.

weight, to give approximate adjusted numbers of hares. We treated set T data in the same way, assuming that all hares in that set were adult.

The estimated average weights of other mammals were minimum weight plus 40% of weight range, from Whitaker (1980); this was closest to averages for five small mammals in our areas for which there were large samples (Durst 1984; Weir, *unpublished*). Bird weights were from University of Alaska Museum data (R. E. G. Clarke, personal communication to DW). We made substantial assumptions, and there are other, untestable assumptions in the use of estimated average weights (Jaksic and Marti 1984). We therefore emphasize unadjusted numbers and relatively broad, $\log_2$ scale prey weight-classes.

Populations of Potential Prey

In the Yukon Territory area in 1980, birds were surveyed by spot-mapping, and small mammals by snap-trapping, in plots totalling 100 ha (Weir, *unpublished*). There were extensive bird and mammal observations for 10 years on the Tuluksak, and birds were surveyed in 1983, by the fixed-width strip census method in plots totalling 130 ha (Petersen et al., *in press*; Weir, *unpublished*). Small mammals were surveyed by snap-trapping in eight areas in 1980-81 (Durst 1984). Bird and mammal censuses in both areas were mainly in woodland, both on virgin ground and on that mined 20-70 years earlier. They were mostly in the valley floors, where Great Horned Owls nested. The abundance of hares when pellets were collected was indicated broadly by dates of peaks in the 10-year hare population cycle.

Results

Pellet Contents

The numbers of items in all sets and average weights are given in Table 1. By adjusted or unadjusted frequency, hares dominated sets A and C, but birds were equally important in set B, and large microtines (here > 31 g) dominated set T. Adjusted numbers were shown by $\log_2$ scale weight-classes (Figure 2). We assumed that birds and fishes in set T were the same as in fresh kills at that nest site in three years. Overall, 50% of items were in classes 5-6 (16-63 g), 12% were in the owls' own weight-class 11, but only 2% were in classes 3-4 (4-15 g).

TABLE 1. Prey items in sets of Great Horned Owl pellets from three central Yukon Territory nests, 1980 (sets A to C), and a western Alaska nest, 1974 (set T). For species < 200 g, the minimum numbers of individuals per set = occurrences in pellets; those of larger species were counted directly, except Snowshoe Hare where the numbers of occurences are shown, with estimated items in parentheses (see also text).

Prey species	Estimated weight in g	n items in pellet sets A	B	C	T	Overall n
Sorex cinereus	5	1	0	1	0	2
S. arcticus	8	1	0	0	0	1
Lepus americanus	adult 1280					
	juvenile 400	57(14)	10(7)	17(13)	14(4)	98(38)
Peromyscus maniculatus	19	1	0	2	0	3
Clethrionomys rutilus	29	5	3	3	12	23
Pheacomys intermedius	25	2	1	1	0	4
Microtus pennsylvanicus	40	2	0	0	8	10
M. oeconomus	47	0	0	0	18	18
M. longicaudus	44	0	2	0	0	2
M. xanthognathus	136	2	0	4	0	6
M. gregalis	37	0	0	0	10	10
Ondatra zibethicus	adult 1050					
	juvenile 550	0	0	0	2	2
Lemmus sibiricus	74	2	1	0	11	14
Synaptomys borealis	27	3	0	1	4	8
Dicrostonyx torquatus	78	0	0	0	3	3
Mustela nivalis	42	0	0	0	2	2
Anatidae	adult 800					
	juvenile 400	0	1	0	—	—
Tetraonidae	adult, three spp. 600	1	8	0	—	—
Aves, others	20-200	0	1	4	—	—
Aves, all		1	10	4	14	29
Salmonidae	800	0	0	0	2	2
Total items with number of hares adjusted		34	24	29	90	177

Bird and fish species in set T were not given. All bird and fish species data are in the text and Table 3. Unidentified small mammals and beetles in sets A to C are omitted from Table 1; they were about 5% of items and a trivial proportion of biomass.

Mammal species in sets A to C were identified by AH from published keys and a small collection of skulls from the Yukon Territory study area, which was checked by S. Macdonald, University of Alaska Museum, Fairbanks. Birds were identified by DW from published sources and material in the Royal Museum of Scotland, Edinburgh. Mammals in set T were identified at the American Museum of Natural History, New York. DW identified fresh kills at the Tuluksak nest site.

Hare Prey and Abundance

Remains in set A were all adult hares, many in winter pelage. Those in sets B and C were about 80% juveniles, with adults in summer pelage; spring and summer predation was represented. Juveniles were about 50% of hare biomass in sets B and C. We assumed that all hares in set T were adult; hares were scarce on the Tuluksak then (below) and Great Horned Owls in Alberta brought only adults to the nest when hares were scarce (McInvaille and Keith 1974). The adujsted numbers of hares were about 85% of prey biomass in sets A to C combined, and about 40% in set T.

The Tuluksak hare cycle crashed about 1972, so that hares were relatively scarce in 1974 (Weir, *unpublished*). Numbers in the central Yukon Territory peaked in 1980-81, so that numbers in our Yukon Territory study area were very high in 1980 (Slough and Jessup 1984).

Small Mammal Prey and Populations

The relative abundance of small mammal species trapped and in owl pellets is shown for both areas in Table 2. Owls in both areas took significantly more large microtines (classes 6-8) and fewer shrews (classes 3-4) than traps did. Similarity between areas was close despite marked differences in species; 9 of 16 species (56%) in Table 2 were recorded in only one area.

Mammal Species Taken and Present

About 29 species within the weight range of owl prey occurred in one or both areas, from Youngman (1975), Durst (1984) and Weir (*unpublished*). Owl pellets contained remains of 16 (55%). Only two of the other 13 were evidently abundant in one or both areas when pellets were collected; the Red Squirrel, *Tamiasciurus hudsonicus*, and the Arctic Ground Squirrel, *Spermophilus parryi*.

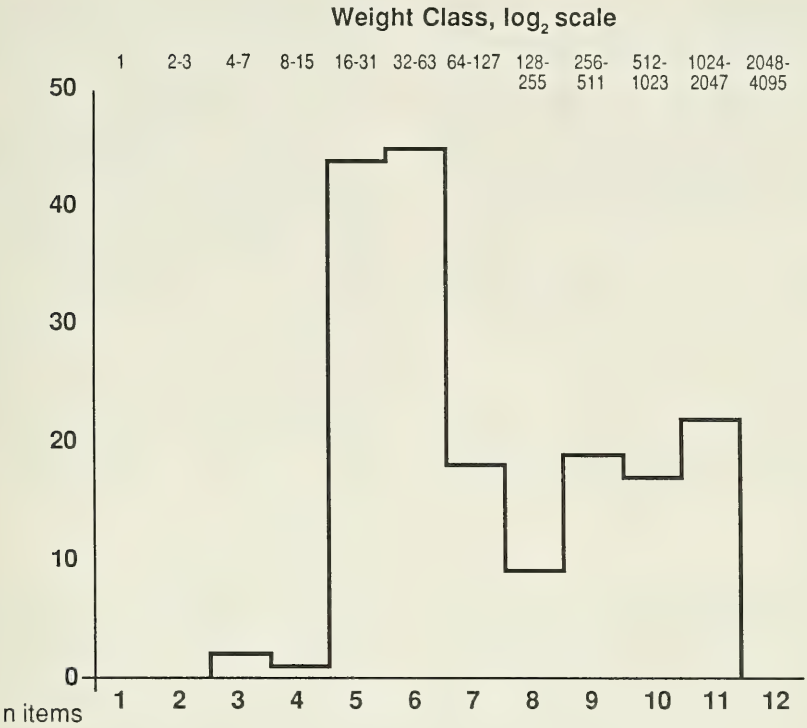

FIGURE 2. Distribution by log$_2$ scale prey weight-classes of adjusted numbers of Great Horned Owl prey items in pellets from three nests in a central Yukon Territory study area and one in western Alaska.

TABLE 2. Percentage and numbers of shrews, of mice and small microtines, and of large microtines, in snap-trap captures and in Great Horned Owl pellets in the central Yukon Territory and western Alaska study areas.

Group, weight range, numbers of species and items	Central Yukon		Western Alaska		Both combined	
	traps	pellets	traps	pellets	traps	pellets
1. shrews (3–8 g)	% = 31.2	7.9	46.2	0	41.4	2.9
4 spp., n = 381	n = 91	3	287	0	378	3
2. mice + small microtines	65.1	57.7	37.4	24.3	46.1	36.5
(19–29 g), 5 spp., n = 460	190	22	232	16	422	38
3. large microtines (37=136 g)	3.8	34.3	16.5	75.8	12.4	60.4
7 spp., n = 176	11	13	102	50	113	63
Totals 1017	292	38	621	66	913	104
Estimated average item weight	22.3	47.6	20.0	46.1	20.7	46.6
(Standard Error)	(0.8)	(6.8)	(0.6)	(2.0)	(0.5)	(2.8)

Species in Yukon traps A, pellets B, Alaska traps C, pellets D; Group 1 — Masked Shrew ABC, Dusky Shrew (*S. monticolus*) AC, Arctic Shrew ABC, Pigmy Shrew (*Microsorex hoyi*) C, Group 2 — Deer Mouse AB, Meadow Jumping Mouse (*Zapus hudsonius*) C, Northern Heather Vole B, Northern Bog Lemming ABCD, Tundra Red-backed Vole ABCD, Group 3 — Meadow Vole ABCD, Tundra Vole CD, Long-tailed Vole B, Yellow-cheeked Vole B, Singing Vole D, Brown Lemming ABCD, Collared Lemming D. Muskrats could not be sampled in trapping programmes and were omitted.

Differences in proportions of groups in trap captures and owl pellets from those in both combined; Yukon shrews, $\chi_1^2 = 5.6$, $P < 0.05$, Alaska shrews, $\chi_1^2 = 29.4$, $P = 0.001$, Yukon large microtines, $\chi_1^2 = 38.4$, $P < 0.001$, Alaska large microtines, $\chi_1^2 = 92.3$, $P < 0.001$.

Bird Prey and Populations

Fifteen birds from Yukon Territory pellets, and seven from fresh kills at the Tuluksak nest site in 1974 and other years, are listed in Table 3. Sixteen (73%) were in weight-classes 7-10, including 11 grouse. In censuses, 14% of 140 pairs of birds in the Yukon Territory area were in classes 7-10, and 7% of 542 on the Tuluksak (Weir, *unpublished*; Weir and Weagle, *unpublished*). In censuses of individual habitat types, the highest proportion of birds in classes 7-10 was 3 of 13 pairs (23%) in a Yukon Territory low-medium shrubs plot; this was significantly lower than the proportion in Yukon area prey $\chi^2_1 = 5.16$, $P < 0.05$).

Other Items

DW found a freshly killed Dolly Varden Trout, *Salvelinus malma*, and an Arctic Grayling, *Thymallus arcticus*, at the Tuluksak nest site. Both were about 800 g. Pellet sets A to C contained a few beetles and non-biological material.

Discussion

Great Horned Owls in Colorado, California, and Chile, and Eagle Owls, *B. bubo*, in Spain were studied mainly in mediterranean-type ecosystems (Jaksic and Marti 1984). They tended to take common lagomorphs, large microtines, rats, galliform birds and other open country birds; they tended not to take other diurnal, arboreal, fossorial, very small or very rare mammals, or small birds.

TABLE 3. Fifteen birds identified from central Yukon Territory Great Horned Owl pellets and seven from fresh kills in three years at the nest site studied on the Tuluksak River, Alaska.

Species or type	Estimated weight in g	Yukon 1980	Tuluksak 1974-7	Overall
adult duck	800	1	0	1
juvenile Pintail (*Anas acuta*)	400	0	1	1
Spruce Grouse (*Dendragapus canadensis*)	550	4	1	5
Ruffed Grouse (*Bonasa umbellus*)	700	1	0	1
Willow Ptarmigan (*Lagopus lagopus*)	600	2	1	3
adult groups spp.†	600	2	0	2
large shorebird	200	0	1	1
unidentified bird	150	1	0	1
small passerines†	20-70	4	3	7
Total items		15	7	22
Estimated average item weight		424	259	379

†Grouse were probably Spruce Grouse or Ruffed Grouse. Small passerines included a Fox Sparrow (*Passerella iliaca*) and a swallow.

Great Horned Owls in central Alberta mainly took Snowshoe Hares or large microtines, pocket gophers, grouse and large wetlands birds when hares were scarce; they strongly tended not to take shrews, squirrels, mice, small microtines and small birds (McInvaille and Keith 1974).

In our much more limited study, owls mainly took Snowshoe Hares, with many more large microtines and more grouse and other birds in the area where hares were scarcer. In both areas, they strongly tended to take the largest microtines and grouse or other relatively large birds, and not to take shrews, tree or ground squirrels, some scarce mammals, or small birds. Close agreement with the other two studies indicated that food habits were like those of Great Horned Owls elsewhere. This agreement suggested that our outline of northern taiga diet might be more representative than would usually be assumed for small samples from areas which were much changed from the undisturbed wilderness state.

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Food Habits of Martens, *Martes americana*, in the South-Central Yukon Territory

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The diet of the Marten (*Martes americana*) was studied in a 14-km² area of the south-central Yukon Territory for three years. The major food group of the Marten was microtine rodents. Seasonally abundant food items, including overwintering and fresh fruits (primarily the Crowberry, *Empetrum nigrum*), birds and Snowshoe Hares (*Lepus americanus*), were also exploited by Marten. The proportional occurrence of Hares in scats exceeded that of Northern Red-backed Voles (*Clethrionomys rutilus*) during January and February 1981 when Hares were abundant and many were starving. Our findings support the views that Marten are microtine specialists, supplementing their diets by opportunistically consuming a wide variety of food items. The common use of the Brown Lemming (*Lemmus sibiricus*) is reported for the first time, while *Microtus* was not commonly used as has been noted in several other North American studies.

Key Words: Marten, *Martes americana*, food habits, Yukon Territory.

Previous studies of Marten (*Martes americana*) food habits have shown that Marten are both dietary opportunists and microtine rodent specialists (reviewed by Buskirk and MacDonald 1984). Marten scats were collected concurrent with studies of Marten population dynamics conducted by the Yukon Department of Renewable Resources (Archibald and Jessup 1984) and with studies of small mammal abundance, and demography and habitat preference of *Clethrionomys rutilus*, the Northern Red-backed Vole (Beare 1984) in south-central Yukon Territory. This paper describes the food habits of Marten and their relationship to the availability of microtine rodent species.

Methods

The study area, described previously by Archibald and Jessup (1984), is in the upper Yukon River Basin (60°45′N, 133°15′W) in the south-central Yukon Territory.

Marten were live trapped at three-week intervals between May and September 1979, 1980, and 1981. Traps were set along eight transects which were positioned 2.8 km apart and averaged 2.0 km in length. Scats were collected from the grid during each session. Winter scats were removed annually in May and were collected November 1980 through March 1981 during Marten radiotracking studies. Each scat was labelled with the collection date.

The scats were washed with water, and their contents were separated into broad categories and dried. Prey remains were identified by comparing them to a reference collection of hair, skulls, teeth, feathers, insects and fruits, and with the aid of keys (Moore et al. 1974; A. J. Kennedy and L. N. Carbyn. 1980. Identification of prey remains from wolf feces with special reference to western Canadian National Parks. Unpublished Canadian Wildlife Service Report, Edmonton, Alberta. 65 pp.). Mammal hairs were cleared in methyl salicylate and imprinted on thermo-plastic film to expose the scale pattern. Medullar structure and scale pattern were then used to identify the hairs. Incidental food items, such as inorganic matter and leaves were disregarded in the analysis. The relative importance of food items is expressed as the percent frequency occurrence of the items in the scats. The scats were grouped by the month in which they were collected for analysis.

The relative abundance and diversity of small mammalian prey species has been documented by Beare (1984). Small mammals were snap-trapped during the spring near the onset of breeding (late May-early June) and during mid-September, near the seasonal peak in numbers of 1979 and 1980, and during the spring of 1981. Four lines, each consisting of 500 Victor Museum Special snap traps baited with peanut butter, were run for three consecutive nights (i.e. 600 trap nights) on each of five habitats considered representative of the Marten study area (Beare 1984). Data from each habitat were pooled for the present study. We followed the scientific nomenclature of Banfield (1974) for mammals, Godfrey (1986) for birds and Hultén (1968) for vascular plants.

Results

A total of 597 Marten scats were analyzed (Table 1). Microtines occurred in 77.9% of the scats with fruit (16.8%), Snowshoe Hare (16.4%), birds (10.7%), and unknown mammals (6.0%) codominants. Four other food groups were each found in < 5% of the scats. Summer and winter food habits are discussed separately.

Summer Food Habits

Microtine rodents occurred in 82.3% of the 481 summer scats, fruit in 20.8%, birds in 12.5%, and Snowshoe Hare (*Lepus americanus*) in 10.2% (Table 1). Sciurids, soricids, cervid carrion, unknown mammals and insects made up the remaining food items in lesser frequencies. The percent frequency occurrence of food groups, including the major microtine and fruit species represented, are presented by collection month in Table 2.

Seven species of microtine rodents were identified in the prey remains. The Northern Red-backed Vole (*Clethrionomys rutilus*) occurred in 72.3% of the scats, the Brown Lemming (*Lemmus sibiricus*) in 14.7% and the Meadow Vole (*Microtus pennsylvanicus*) in 6.4%. The Northern Bog Lemming (*Synaptomys borealis*), Longtailed Vole (*M. longicaudus*), Heather Vole (*Phenacomys intermedius*) and Deer Mouse (*Peromyscus maniculatus*), listed in descending order of importance, occurred infrequently (< 5% of total scats). The relative abundance of small mammals (Table 3) shows an overall predominance of Red-backed Voles (85.7% of total captures), followed by Meadow Voles (5.3%) and Brown Lemmings (2.4%). Microtines increased in abundance by as much as eight-fold over the summer. The Deer Mouse was not captured, although it did occur in some scats. Brown Lemmings were consumed in greater proportion than they were available relative to other small mammal species in June-July 1979 and August 1980.

The Crowberry (*Empetrum nigrum*) was the predominant fruit consumed by Marten. Occurring in scats less frequently were Bilberry (*Vaccinium uliginosum*), Lowbush Cranberry (*V. vitis-idaea*), Red Currant (*Ribes triste*) and Wild Rose (*Rosa acicularis*). Other fruits that were available on the study area, but were not identified in scats were Red Raspberry (*Rubus idaeus*), Bearberry (*Arctostaphylos uva-ursi*), and Northern Commandra (*Geocaulon lividum*).

Thirteen of 64 bird remains were tetraonids, one of which was identified as a Spruce Grouse (*Dendragapus canadensis*). In addition, 24 scats contained egg shells and 28 contained unidentified feathers. Other tetraonids in the area included Ruffed Grouse (*Bonasa umbellus*), Blue Grouse (*Dendragapus obscurus*) and Willow Ptarmigan (*Lagopus lagopus*). Spruce Grouse are undoubtedly the most common (D. Mossop, personal communication.).

Insect remains occurred in 26 summer scats. Most (69.2%) were identified as hymenopterans.

Beare (1984) trapped Dusky Shrews (*Sorex obscurus*) and Masked Shrews (*S. cinereus*) on the study area. The Navigator Shrew (*S. palustris*) and Pygmy Shrew (*Microsorex hoyi*) are also known to occur in the region. *Sorex* spp. were identified in 14 of the scats.

Six species of the sciurid rodents occur in or near the study area including Red Squirrels (*Tamiasciurus hudsonicus*), Arctic Ground Squirrels (*Spermophilus parryi*), Northern Flying Squirrels (*Glaucomys sabrinus*), Hoary Marmots (*Marmota caligata*), Woodchucks (*M. monax*) and Least Chipmunks (*Eutamias minimus*). Only Red Squirrels and Least Chipmunks occurred in Marten scats and in low frequencies (five food items).

Local cervids include Moose (*Alces alces*) and Caribou (*Rangifer tarandus*). Calf Moose carrion was identified in two scats from June 1980.

TABLE 1. Percent frequency occurrence of food items in Marten scats collected in south-central Yukon Territory, 1979–1981.

	June-August 1979 *n* = 102	May-August 1980 *n* = 243	November 1980 to March 1981 *n* = 116	June-August 1981 *n* = 136	Summer Total *n* = 481	Overall *n* = 597
Microtine	76.5	84.0	59.5	83.8	82.3	77.9
Fruit	28.4	25.9	0.0	5.9	20.8	16.8
Snowshoe Hare	3.9	11.9	42.2	11.8	10.2	16.4
Bird	9.8	10.3	3.4	19.1	12.5	10.7
Unknown mammal	6.9	5.3	8.6	4.4	5.4	6.0
Insect	9.8	2.9	0.0	6.6	5.4	4.4
Soricid	1.0	4.9	0.0	0.7	2.9	2.3
Sciurid	1.0	1.2	0.0	0.7	1.0	0.8
Cervid	0.0	0.8	1.7	0.0	0.4	0.7

TABLE 2. Monthly percent frequency occurence of major food items in Marten scats collected in south-central Yukon Territory, 1979-1981.[1]

	1979			1980						1981						Summer Months	Winter Months	Overall
	June ($n = 21$)	July ($n = 29$)	August ($n = 23$)	May ($n = 32$)	June ($n = 96$)	July ($n = 28$)	August ($n = 31$)	November ($n = 23$)	December ($n = 12$)	January ($n = 23$)	February ($n = 16$)	March ($n = 56$)	June ($n = 62$)	July ($n = 20$)	August ($n = 51$)	($n = 481$)	($n = 116$)	($n = 597$)
Microtine (total)	85.7	86.2	73.9	62.5	91.7	57.1	87.1	78.3	75.0	45.5	37.5	76.2	85.5	80.0	84.3	82.3	59.5	77.9
Clethrionomys rutilus	38.1	37.9	47.8	28.1	46.9	17.9	61.3	52.2	50.0	27.3	31.3	52.4	64.5	45.0	52.9	72.3	40.0	66.0
Lemmus sibiricus	23.8	7.2	4.3	3.1	11.5	3.6	16.1	17.4	8.3	0.0	6.3	0.0	1.6	0.0	3.9	14.7	5.2	12.9
Microtus pennsylvanicus	4.8	3.4	0.0	3.1	7.3	7.1	0.0	0.0	0.0	2.3	0.0	0.0	3.2	15.0	5.9	6.4	0.9	5.4
Synaptomys borealis	4.8	3.4	0.0	3.1	3.1	0.0	0.0	0.0	0..0	0.0	0.0	4.8	0.0	0.0	2.0	3.1	0.9	2.7
Phenacomys intermedius	0.0	0.0	0.0	3.1	2.1	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	1.3
Peromyscus maniculatus	0.0	0.0	0.0	0.0	1.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.8
Microtus longicaudus	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.8	0.0	0.7
Empetrum nigrum	4.8	3.4	34.8	31.3	28.1	17.9	12.9	0.0	0.0	0.0	0.0	0.0	6.5	0.0	3.9	12.9	0.0	10.4
Other fruit	0.0	0.0	8.7	0.0	4.2	0.0	12.9	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	2.3	0.0	1.8
Bird	14.3	10.3	8.7	15.6	10.4	10.7	6.5	0.0	8.3	6.8	0.0	0.0	16.1	25.0	19.6	12.5	3.4	10.7
Lepus americanus	4.8	6.9	4.3	31.3	10.4	14.3	0.0	26.1	33.3	50.0	68.8	28.6	21.0	5.0	3.9	10.2	42.2	16.4

[1] Excluding occurences of unknown microtines.

TABLE 3. Total catch and relative abundance (catch per 100 trap-nights) of small mammals in the south-central Yukon Territory, 1979-1981. Based on 3000 trap-nights per session.

	1979			1980			1981	
	Spring	Fall	*n*	Spring	Fall	*n*	Spring	*n*
Clethrionomys rutilus	1.67	6.13	234	1.17	9.07	307	1.27	38
Microtus pennsylvanicus	0.17	0.43	18	0.03	0.50	16	0.07	2
Lemmus sibiricus	0.13	0.13	8	0.03	0.17	6	0.07	2
Phenacomys intermedius	0.10	0.13	7	0.10	0.07	5	0.10	3
Synaptomys borealis	0.03	0.03	2	0.00	0.10	3	0.07	2
Microtus longicaudus	0.00	0.00	0	0.00	0.03	1	0.03	1
Sorex obscurus	0.00	0.17	5	0.00	0.10	3	0.00	0
Sorex cinereus	0.00	0.17	4	0.07	0.20	8	0.00	0

Winter Food Habits

Fecal analyses showed microtine rodents in 59.5% of the winter scats, Snowshoe Hares in 42.2%, cervid carrion (1.7%), unknown mammals (8.6%) and birds (3.4%). Fruit, insects, soricids and sciurids were absent (Table 1).

The Northern Red-backed Vole was the predominant microtine identified in prey remains (40.0%). The Brown Lemming (5.2%), Meadow Vole (0.9%) and Northern Bog Lemming (0.9%) were also present (Table 2). Heather Voles, Deer Mice and Longtailed Voles were absent. Bird remains were identified as tetraonids in two cases. One scat contained eggshell. Cervid carrion was Moose in at least two cases.

Discussion

Microtine rodents were the most common food of Marten in the south-central Yukon Territory during all months sampled except January and February 1981, when Snowshoe Hares predominated the diet. Northern Red-backed Voles consistently occurred with greater frequency than other microtines. The Northern Red-backed Vole was also the most common microtine and was ubiquitous in the study area (Beare 1984). It has dominated the diet of Marten in several northern locations (Lensink et al. 1955; Quick 1955; Boles 1975; More 1978; Douglass et al. 1983; Buskirk and Macdonald 1984). Fruits, birds, Snowshoe Hares and insects were seasonally important.

The diet of Marten in the Yukon Territory was not predominated by *Microtus* as has been documented in several other studies (Lensink et al. 1955; Weckwerth and Hawley 1962; Francis and Stephenson 1972; Douglass et al. 1983; Buskirk and MacDonald 1984). The Brown Lemming was, however, consumed in a proportion greater than its relative abundance. Brown Lemmings, like *Microtus*, exhibit a clumped distribution in meadows (Krebs and Wingate 1976). This factor, or perhaps its association with a recognizable habitat, might contribute to energy efficient foraging on the part of the Marten, and may account for the common use of this species. *Microtus* was more commonly snap-trapped, although it occurred less frequently in Marten scats, than Brown Lemmings.

Snowshoe Hares were abundant in the southern Yukon Territory during the study period and reached a cyclic peak in abundance from 1980-81 to late winter 1981-82 (Boutin et al. 1986). Snowshoe Hare carrion (from starved individuals) and vulnerable Hares (nutritionally- and cold-stressed) were common during the winter of 1980-81 (Boutin et al. 1986) and possibly during the early summer months of 1980 and 1981 when its occurrence in Marten scats was most frequent. A successful Snowshoe Hare kill by a Marten after a chase was observed in the study area during the winter of 1979-80 by WRA. A high frequency of occurrence (≥ 20%) of Snowshoe Hare in Marten scats or stomachs at a time when Hares were at or near their cyclic peak has also been reported by Quick (1955), Boles (1975), Raine (1981), and Thompson and Colgan (1987). Voles were concurrently abundant in the latter two cases, as well as during the present study. Use of hare by Marten was also common in Newfoundland (Bateman 1986), where it was one of a few available prey species.

Crowberry fruit overwinter on the plant and remain intact until late summer (July-August) when deterioration occurs. New fruit is produced by late August-September, depending on weather conditions (C. Kennedy, personal communication). The use of Crowberry was highly variable between months (Table 2), suggesting the exploitation of new fruit in August 1979 and previous years' fruit in May to July 1980. The low occurrence of fruits in 1981 Marten scats was also noted by Buskirk and MacDonald (1984), and may have been due to a regional crop failure.

The seasonal utilization of fruits, birds, Snowshoe Hares and other food items is related to seasonal abundance and availability (More 1978;

Buskirk and MacDonald 1984). An exception, shrews, are believed to be taken proportionally less than other small animals (Cowan and McKay 1951; Newby 1951).

Our findings support the views that Marten are microtine specialists with underlying specific preferences (Buskirk and MacDonald 1984), supplementing their diets by opportunistically consuming a wide variety of foods (Simon 1980).

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Migration of Larids at Beauharnois, Quebec, 1967-1980

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Larids (jaegers, gulls, and terns) were casually, and then systematically, observed (591 counts) over a 14-year period near Beauharnois, Quebec, to determine species, numbers and phenology. Migration patterns and numbers were established for 22 species. Ten new species for the Montreal area were recorded and three previously recorded Palearctic species were found to occur far more regularly than expected. Data on migration routes of Ring-billed Gulls, *Larus delawarensis*, Herring Gulls, *Larus argentatus*, and Great Black-backed Gulls, *Larus marinus*, is provided from recovery of banded birds.

Key Words: Larids, Quebec, Lac St-Louis, Beauharnois, species, phenology, numbers, routes.

Published reports on the occurrence of jaegers, gulls and terns in the Montreal region occurred from the 1860s to the 1970s in various local and Canadian publications (Ouellet 1974). Casual observations in 1967 revealed some species that had not been recorded, and that details of phenology, numbers and migration routes were scarce. Casual observations turned to systematic counts at the Beauharnois power dam (Figure 1) on 29 July 1969 and continued to 27 December 1980. Some of the data gathered have been published (P.Q.S.P.B. 1965-1980; Ouellet 1974; David 1980; Holohan et al. 1984). The 591 systematic counts over a 137-month period revealed migration patterns for the common species and clarified the status of other species. Status changes included previously unrecorded species now known to occur regularly in small numbers, some previously recorded species now known to occur more frequently, and some common species that appear to be increasing in number. Correlation of data with other eastern North American studies has not yet been attempted.

Study Area

Lac St-Louis (Figure 1) is one of several local concentration areas. It is a gathering place for gulls that may have arrived by routes from the west — the Great Lakes system; the north — James Bay/Ottawa River systems; the east — Atlantic Ocean and St. Lawrence River; and the south — the Hudsonian/Richelieu systems. Lac St-Louis is a widening of the St. Lawrence River near the town of Beauharnois, Quebec (45°27′N, 73°54′W). It receives most of the water flow of the Great Lakes-St. Lawrence River system through a canal that supplies a hydro power station and ship locks. It was also chosen for the study because of possible close eye-level approach (often less than 10 metres) to flying gulls from a highway-pedestrian bridge which runs just below the power house and because of easy automobile approach to lawn-resting birds.

Methods

Only casual observations were made in 1967-69. Systematic data were collected on 591 days over 137 months by J.S. (1969-77), S.H. (1969-79) and R.B. (1974-80). The breakdown of systematic counts was 1969-34, 1970-68, 1971-40, 1972-45, 1973-51, 1974-51, 1975-58, 1976-58, 1977-53, 1978-48, 1979-47, 1980-38. The counts by month were January-44, February-15, March-29, April-32, May-59, June-23, July-29, August-60, September-68, October-68, November-110, December-54.

Counts made during October-January, the main migration period, started shortly after dawn and went on until at least early afternoon. Most counts were on weekends but mid-week counts were also made at peak migration times. During June-August, when few birds (≤ 100) were present counts, could be completed in one hour.

Estimates of lawn-resting flocks and flying birds were made during each count. The principle method was to view lawn-resting flocks from the height of the ship locks. Numbers in a limited area were counted and then the numbers of the entire group extrapolated from it. Several counts were made and averaged to decrease inaccuracy. Photographs of various sized flocks were obtained on several occasions to aid the above technique. Flying birds were difficult to count as they milled about constantly, and efforts were made to obtain counts when the majority of larids were lawn-resting.

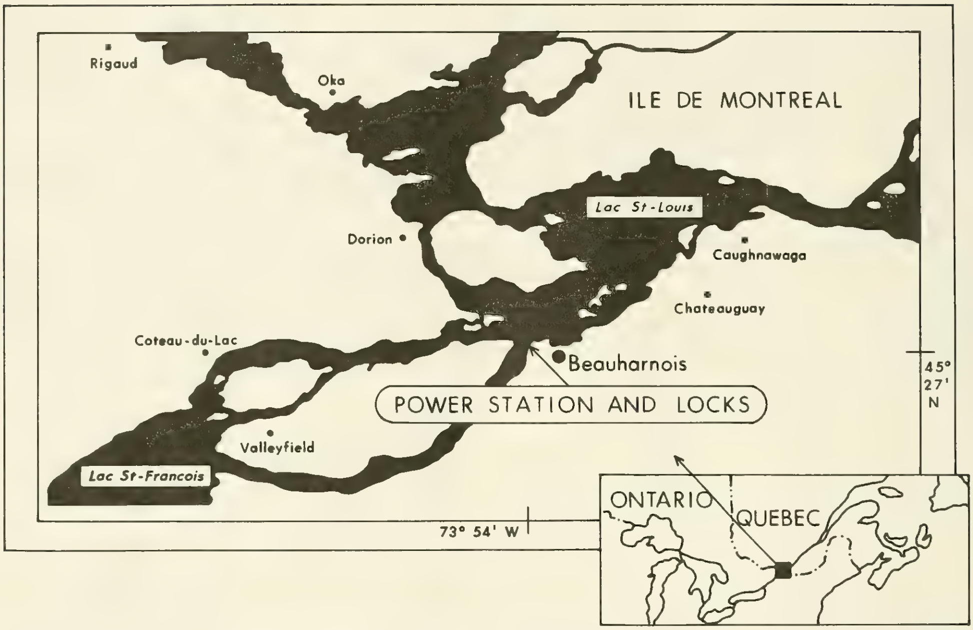

FIGURE 1. Map showing the location of the study site, the Beauharnois power dam in southwestern Quebec.

Counts were analysed using five-day periods (73) of the calendar year. Mean dates were calculated using all dates for all years.

Results

The following annotated list includes all species seen at the site from July 1967 to 27 December 1980. The species sequence follows the A.O.U. (1983) check-list. Data of peak migration times for the eight most common species are shown graphically in Figure 2. Species data are summarized in Table 1.

POMARINE JAEGER, *Stercorarius pomarinus*. One adult dark phase bird 1-6 November 1979.

PARASITIC JAEGER, *Stercorarius parasiticus*. Two immatures 20 November 1976, one 11-12 November 1978, and one 1 November 1979.

LAUGHING GULL, *Larus atricilla*. One adult 1 September 1969, one sub-adult 1-3 September 1969, one adult 4 October 1970, one immature 13 May 1976, one immature (photographed) 23 October-13 November 1977, one adult in winter plumage (photographed) 4-11 November 1979, and one first-winter 11-23 November 1980.

FRANKLIN'S GULL, *Larus pipixcan*. One sub-adult 26 September 1970, one immature 5 October 1974, one adult in summer plumage 20 July 1976, one adult (photographed) 17 August 1980, and one adult 23 November 1980.

LITTLE GULL, *Larus minutus*. Migrant in small numbers in most years. First recorded 17 August-13 September 1969; two adults. Not recorded in 1970 or 1971 but recorded with increasing frequency 1972-80. There were over 64 reports involving over 168 individuals. The largest day count was seven and the mean (N = 37) was three birds. Recorded on spring migration in three years and in autumn in ten years. Earliest spring report 10 May and the latest 28 May. Mean dates for autumn were 14 August to 19 September with the latest 2 November. The majority of adults and immatures occurred August to November with the earliest 14 July and latest 2 November.

COMMON BLACK-HEADED GULL, *Larus ridibundus*. A summer-plumage adult (photographed) 8-10 May 1975, a first-winter bird (photographed) 21-25 November 1978, one first-winter bird 27-28 December 1979, one juvenile (photographed) 16-21 August 1980 and two 11 November 1980.

BONAPARTE'S GULL, *Larus philadelphia*. April-May and August-December. In most years (1-5) immatures spent June-August in the area. Earliest spring report was 8 April, mean migration 22 April-4 June and the latest 23 June. In late April numbers built up rapidly and a concentration of adults occurred 8-13 May. Largest count 250. Mean southward migration dates 28 July-17 November with the latest 1 December. Flocks which returned in late July were smaller than those in spring. Numbers fluctuated between 10 and 60

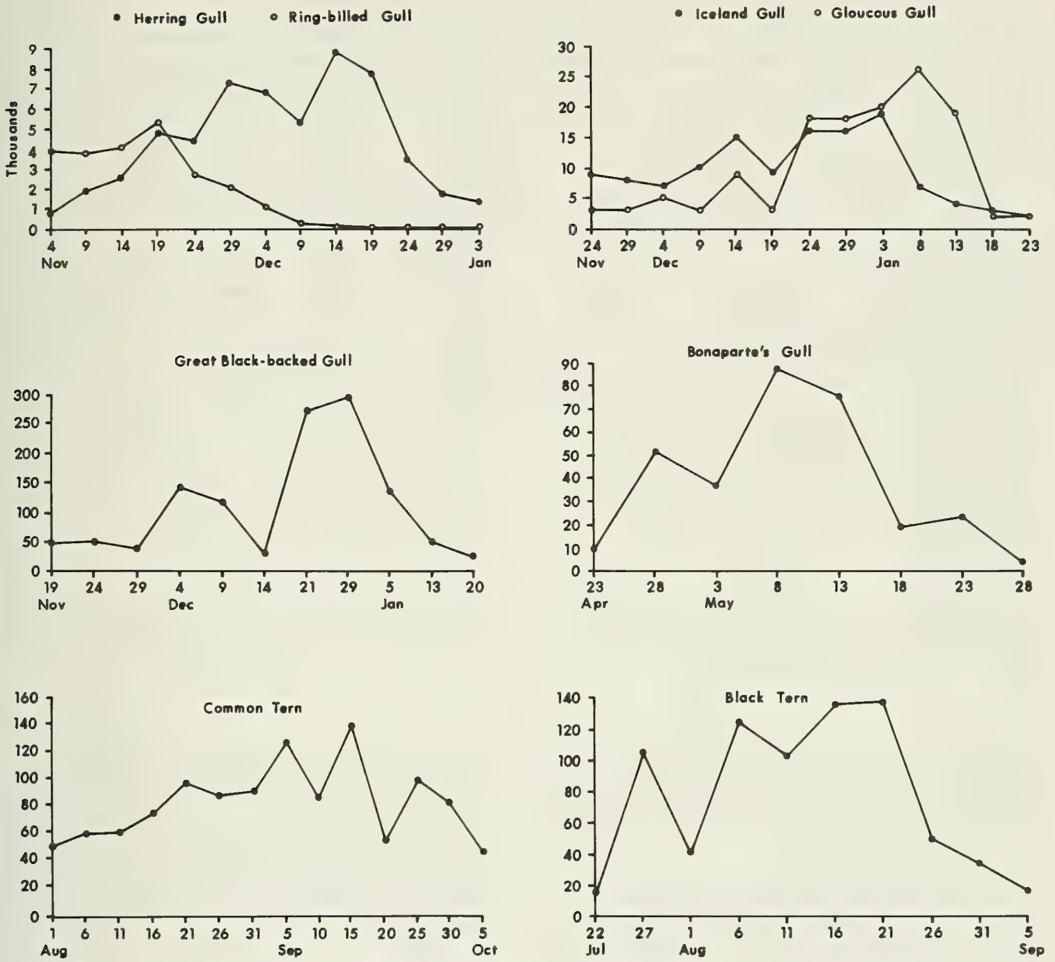

FIGURE 2. Peak migration times of the eight most abundant species. The abscissa covers monthly five-day intervals and the ordinate the mean number of birds in each five-day interval.

and only twice reached ≥ 100. July-August flocks contained mostly adults with juveniles. Small numbers (≤ 16, N = 39) remained into November most years.

RING-BILLED GULL, *Larus delawarensis*. Nesting bird in area. Several colonies occur within 40 km of Beauharnois (David et al. 1977). Earliest spring arrival was 18 March, mean arrival 29 March. No build-up of birds in spring (maximum = 1000); in the post-breeding season local colony birds (maximum = 2000) used the area June-August. Numbers then dropped as birds moved out to feed. Birds returned to the dam in late October. Counts then built up rapidly to peak 17-21 November (N = 18, Mean = 5706, S.D. = 3279). Day counts peaked usually at ≤ 5700 but many counts (N = 12) of > 10,000 were recorded. Mean departure date 14 December with the latest 26 January.

HERRING GULL, *Larus argentatus*. Main migration November to mid-January. Earliest arrival 3 March, mean arrival 21 March. Southward migration counts built rapidly around 20 October until peak 12-16 December. Daily mean peak was ≤ 8857 but counts of > 10,000 (N = 19) were recorded. When severe snowstorms occurred most birds moved out of the area. Mean departure date 20 January with the latest 13 February.

THAYER'S GULL, *Larus thayeri*. Possibly a very rare migrant in small numbers. Our study recorded 36 birds showing the characteristics of Thayer's Gulls. Earliest date 22 October and latest 7 January with mean dates 27 November – 1

TABLE 1. Species data for Beauharnois power dam ranked in order of species' abundance. A. Total number of individuals (591 counts). B. Percentage of total C. Maximum daily totals. D. Number of days recorded out of 591.

Species	A	B	C	D
Herring Gull	696 708	54.6	15,000	422
Ring-billed Gull	533 803	41.8	15,000	427
Great Black-backed Gull	15 151	1.2	500	323
Common Tern	11 246	0.9	350	206
Black Tern	8 638	0.7	500	145
Bonaparte's Gull	6 446	0.5	250	271
Iceland Gull	1 326	0.1	50	169
Glaucous Gull	994	0.1	100	139
Little Gull	168	—[a]	7	64
Black-legged Kittiwake	74	—	5	56
Thayer's Gull	36	—	3	32
Lesser Black-backed Gull	20	—	1	20
Ivory Gull	20	—	3	7
Laughing Gull	20	—	2	19
Common Black-headed Gull	11	—	2	10
Parasitic Jaeger	9	—	2	7
Arctic Tern	7	—	3	4
Forster's Tern	7	—	2	6
Sabine's Gull	6	—	1	6
Franklin's Gull	5	—	1	5
Pomarine Jaeger	2	—	1	2
Caspian Tern	2	—	2	1

[a]Indicates too few to compute

December. Largest daily count seven, but usually one or two. Most were adults. Detailed notes were made of birds and photographs taken but collecting was impossible.

ICELAND GULL, *Larus glaucoides*. Mean migration period 10 November – 10 February. Earliest record 23 October and latest 5 April. Bird numbers started building up 4 December and reached peak 1-5 January. Numbers then fell rapidly and few birds were present by late January. Mean flock size was 11 (N = 89) with the largest 50. Birds at close range showed the characteristics of the subspecies *L. g. kumlieni*.

LESSER BLACK-BACKED GULL, *Larus fuscus*. One adult 15-17 November 1972 (photographed). One adult 23-29 November 1975. One adult 4 December 1976. One adult *L. f. intermedius* 20 November-3 December 1977 (found dead, now specimen number 65883. National Museum of Natural Sciences, Ottawa). One second-winter bird 15-29 November 1980 (photographed). One third-winter bird 30 November-10 December 1980 (photographed).

GLAUCOUS GULL, *Larus hyperboreus*. Mean migration period was 17 November-1 February. Earliest birds recorded 10 October and the latest 10 April. Numbers started increasing 19 December and reached peak 6-10 January. By 18 January numbers declined rapidly but single birds have stayed into March and once to April. Mean flock size 12 (N = 68) with 100 the largest.

GREAT BLACK-BACKED GULL, *Larus marinus*. Seen every month. Earliest bird on the northward migration 5 March, with mean arrival 3 April. Peak of the southward migration 27-31 December. Mean departure date was 28 January, the latest 26 February. During April-August >10 non-breeding gulls remained. Mean of day counts October-January was 78 (N = 151) but counts of >500 (N = 4) were recorded in late December – January. Average birds per count during peak migration month (14 December-14 January) increased by 500% to 1980.

BLACK-LEGGED KITTIWAKE, *Rissa tridactyla*. First record was an immature 8-13 September 1969 (Steeves 1971). Mean migration dates 6 November-5 December, the earliest 11 August and latest 15 December. One spring report of an adult seen 30 April 1980. Most records were of single immatures, but one count included five birds.

SABINE'S GULL, *Xema sabini*. An immature (photographed) 7-14 September 1975 and an immature 3-6 September 1980.

IVORY GULL, *Pagophila eburnea*. Three immatures 17-27 January 1976 (photographed); three sub-adults 6-13 January 1979 (photographed).

CASPIAN TERN, *Sterna caspia*. Two seen 18 July 1967.

COMMON TERN, *Sterna hirundo*. A few pairs (≤ 5) breed in the dam area. Mean date for spring arrival 1 May and autumn departure 14 October.

Earliest 23 April and latest 12 November. Northward migration flocks were usually small (≤ 50, N = 60) with the largest numbers in mid-May. Numbers dropped rapidly in late May. Southward migration numbers built up around 22 July and reached peak 13-17 September, then decreased rapidly. Mean size of southward migration flocks was 83 (N = 101), the largest 350.

ARCTIC TERN, *Sterna paradisaea*. Difficult to identify at a distance and may be more common. Three seen 10-11 June 1972 (Godfrey 1973) and one 17 September 1973.

FORSTER'S TERN, *Sterna forsteri*. One 21 August 1977, two 30 April 1978, one immature 28 July 1978, and one adult 25-27 August 1978.

BLACK TERN, *Chlidonias niger*. A few pairs (≤ 5) breed near the dam. Mean date for spring arrival 7 May and autumn departure 14 September. Earliest report 3 May and latest 26 September. Largest daily northward migration counts were 50 (N = 5) Southward migration numbers increased around 17 July and reached peak 14-18 August. Numbers then decreased rapidly and by 5 September few birds (≤ 18) remained. Mean size of August flocks 114 (N = 36) and the largest daily count 500.

Discussion

Of the species occurring in very small numbers, only Pomarine Jaegers, Parasitic Jaegers, Laughing Gulls, and Caspian Terns had been reliably reported at the Montreal area prior to 1965 (Ouellet 1974). Several of the ten new species recorded are particularly interesting because they appear to be increasing in North America (Godfrey 1986).

Little Gull, Lesser Black-backed Gull and Common Black-headed Gull are three Palearctic species that are becoming more common in North America (A.O.U. 1983; Cramp 1983; Godfrey 1986). The sighting of Little Gull was expected, but its rapid numerical increase to the ninth most numerous species was unexpected (Table 1). It is increasing in Canada and has nested (Godfrey 1986), but it seems to fluctuate in numbers (Cramp 1983). Little Gulls in breeding plumage appeared in May during three years, presumably on their way to nesting areas in the St. Lawrence-Great Lakes system. In 1973 and 1975 adults accompanied by juveniles returned in late August or early September. Immature birds have spent six summers at the dam but the majority occurred with adults from August to November. After our study the species was found nesting at LaSalle, 25 km east of the dam (Godfrey 1986).

The Common Black-headed Gull has nested in Canada (Godfrey 1986). It could increase rapidly if it were to follow the European pattern (Cramp 1983), but its numbers in our area were fewer than those of the Little Gull. Some individuals may have been overlooked, as the species is difficult to distinguish from distant-flying Bonaparte's Gulls.

North America's Lesser Black-backed Gulls are increasing in frequency; however, there are no known nesting records (Godfrey 1986). Numbers at the dam were low but may increase, following the Canadian pattern (Godfrey 1986).

The eleven other seldom-recorded species nest in North America (A.O.U. 1983) and probably have occurred in most years, but their detection depends on observer interest and viewing conditions. During storms most observers stay indoors, but such conditions can lead to grounded birds and detection of previously unrecorded species. Arctic Terns were found under such conditions. A re-examination of inland data indicated that some Arctic Terns use an overland route to James Bay in spring (Godfrey 1973). Another example was that the Black-legged Kittiwake, previously unrecorded, was a regular visitor during November storms. Viewer interest and conditions clearly played a part in its detection. We believe that, given adequate viewer field time, most seldom-recorded species can be detected annually at the site.

Over 96% of the gulls recorded were Herring Gulls and Ring-billed Gulls (Table 1). Although they have been extensively studied elsewhere (David et al. 1977; David 1980; Ludwig 1974; Moisan and Poulin 1967; Southern 1974a, 1980), we studied these species to obtain much-needed data on their numbers, routes and chronology of migration.

The study of Ring-billed Gull movement was complicated because of the presence of both local nesting birds and staging migrants. To 31 December 1980 there were 336 local band recoveries, mostly of birds banded in the Great Lakes colonies and recovered in the Montreal area. Most were banded as chicks and were recovered during their first winter. There were also 236 recoveries of birds banded around Montreal and recovered coastally from New York south to the Caribbean (majority North Carolina to Florida). This dispersal pattern has been described in the literature (Ludwig 1974; Southern 1974, 1980). There were 33 recoveries of locally-banded birds in the Gulf of St. Lawrence towards Sept-Iles. It would appear that most of the birds in the study area go directly to the east coast, possibly down the Richelieu/Hudson rivers, but a small proportion wander along the St. Lawrence River to the gulf and south along the coast.

The Herring Gull is not a common nesting bird near Montreal. Most birds likely originated from colonies on the Great Lakes (Cooke and Ross 1972), Quebec's interior, or the Gulf of St. Lawrence (Moisan and Poulin 1967). There were 153 Montreal-area band recoveries to 31

December 1980 (data from Bird-banding Office of Canadian Wildlife Service). Most were banded on the Great Lakes but 20 were from Gulf of St. Lawrence colonies. One was of a bird banded north of Winnipeg. Most recoveries were of first-year birds, found during August-December, with only seven recoveries in February-May. There were no recoveries from interior Quebec; this probably reflects the absence of banding in the area. Conversely, the heavy bias toward recoveries of birds banded as chicks on the Great Lakes probably results from extensive banding in that area. Colonies in the Gulf of St. Lawrence are also likely sources of migrants (Moisan and Poulin 1967).

There were eight band recoveries of Great Black-backed Gulls in the Montreal area. All were of birds banded as chicks in the Rivière-du-Loup and Trois Pistoles areas of Quebec. Six were recovered within four months of banding, two after ten and eleven months, respectively.

The main attraction for all species was the amount of food available. During autumn, large numbers of fish, mainly Alewife, *Alosa pseudoharengus*, pass through the power turbines and float in a dead or dying condition below the dam. These fish also seem particularly sensitive to rapid temperature changes; this sensitivity leads to mass die-offs (Scott and Crossman 1973). This could explain the presence of large numbers of larids during the late months of the year. The number of larids present at peak times was consistent from year to year, but could change rapidly with a change in the fish population.

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Interlake Variations of Bald Eagle, *Haliaeetus leucocephalus*, Populations in North-central Saskatchewan

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Nemeiben, Besnard and four other lakes in north-central Saskatchewan were surveyed by boat in 1984 to determine the status of Bald Eagle (*Haliaeetus leucocephalus*) populations. Additional aerial and boat surveys were conducted on Nemeiben and Besnard lakes in 1986 and 1987. Results of the 1984 survey showed that Nemeiben Lake, only 35 km east of Besnard Lake and superficially similar to it in size, had much lower Bald Eagle density and productivity (young fledged/occupied breeding area) than Besnard Lake. Results from surveys on four smaller lakes located between Besnard and Nemeiben lakes showed eagle density and productivity were similar to the Besnard population. Surveys in 1986 and 1987 confirmed that Nemeiben Lake continued to have significantly fewer eagles of all age classes. The reasons for this low population in an apparently good region for Bald Eagles are uncertain, but indicate that important, yet poorly understood, factors can limit eagle density.

Key Words: Bald Eagles, *Haliaeetus leucocephalus*, habitat, human disturbance, population, Saskatchewan.

Continuing development of access roads, tourist facilities and private cabins in northern Saskatchewan make evaluation of the effects of human-induced changes on wildlife populations increasingly important. Interpreting such effects depends on an understanding of the natural variability in such populations. Bald Eagles (*Haliaeetus leucocephalus*) nest along the shores of many of the lakes and rivers in north-central Saskatchewan (Whitfield et al. 1974). Even superficially similar lakes may have considerable differences in eagle density. Besnard Lake, on the southern boundary of the Precambrian Shield, has a sizable, well-studied population of Bald Eagles, which has been relatively stable from 1968 to 1987 (Gerrard et al. 1983; Gerrard, Bortolotti, and Dzus, unpublished data). In contrast, Nemeiben Lake, only 35 km east of Besnard Lake, appeared to have fewer eagles, based on comments of people familiar with this lake and previous, partial aerial and boat surveys (Davis 1966; Gerrard, unpublished data). Nemeiben Lake has slightly more, and longer, recreational cottage development, but it is superficially similar to Besnard Lake in size, surrounding forest habitat and fish species (Koshinsky 1964; Chen 1974).

The present study was conducted to obtain detailed data on the Bald Eagle population of Nemeiben Lake. A chain of lakes between Besnard and Nemeiben lakes was included in the study to ascertain whether the population characteristics of eagles on these lakes more closely resembled those on Besnard Lake or Nemeiben Lake.

Study Area

All six lakes are situated near the southern boundary of the Canadian Precambrian shield in north-central Saskatchewan. Besnard Lake (55°20′ N, 106°00′ W) and Nemeiben Lake (55°20′ N, 105°25′ W) have approximate total shoreline lengths of 400 km and 416 km, respectively. The "mid-lakes", Gull, Morning, Triveet, and Clam lakes, are smaller, lie between the two larger lakes (see Figure 1) and have a combined shoreline length of approximately 360 km. Further details of the study area have been previously discussed (Whitfield et al. 1974; Gerrard and Gerrard 1985).

Nemeiben Lake is 27 km northwest of La Ronge and has had road access since 1958; Besnard Lake is about 65 km northwest of La Ronge and has been accessible by a gravel road since 1973. Road access to Morning Lake is by an old logging road; Gull, Triveet and Clam lakes are accessible only by float plane or portage. Besnard Lake has 69 private and commercial cottage sites, while Nemeiben lake has 80, and the mid-lakes 23. A 1.6-km buffer zone is maintained between cottages, active trapper's cabins, and any highway or road.

Methods

Methodology followed censuses designed for Besnard Lake (Gerrard and Gerrard 1985). Using forestry inventory maps and a map wheel, we divided the shorelines of the lakes into 8-km sections and numbered them consecutively. Census of each lake consisted of surveying odd and even-numbered sections separately. Surveying half the lake requires less time than a full survey, reduces the probability of counting birds that fly ahead of the boat into the next section being counted twice, and produces precise estimates of adults, immatures and nests. We used a motor boat or motorized canoe, travelling 8-16 km/h about

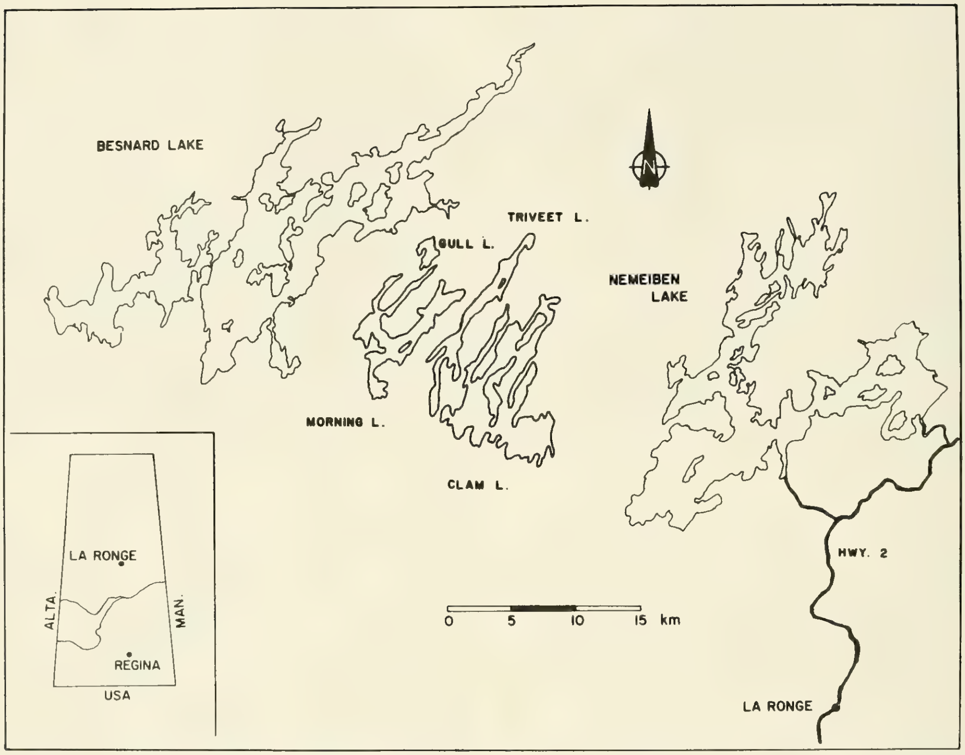

FIGURE 1. Map of study area showing Besnard, Nemeiben, Gull, Morning, Triveet, and Clam lakes in north-central Saskatchewan.

100 m from shore during daylight hours. Initial surveys on all six lakes were conducted by observers with no previous knowledge of nest sites to ensure that all lakes were treated equally. Reduced visibility caused by moderate to heavy rain showers, high winds (> 32 km/h), thick fog or smoke resulted in a temporary cessation of the survey. Surveys were carried out in May–June and July–August; these correspond to the activity and productivity flights conducted in most studies utilizing aerial surveys (Fraser et al. 1983).

During each survey the following data were recorded: (1) location, age (adult, immature, young of the year) and behaviour of each eagle seen; (2) location of each breeding area (nest(s)). Breeding areas were recorded as empty, occupied, active and/or successful (Gerrard et al. 1983). Careful searches were conducted when an adult's behaviour suggested the presence of a nest or when adults were repeatedly seen in an area. On the July–August surveys, enough time was spent observing successful nests to be confident of an accurate count of the number of young. Confirmation of eaglets seen was established, as many of the young were banded. Population estimates for each lake were calculated by a method used on Besnard Lake and the mid-lakes previously (Gerrard and Gerrard 1985). Proc GLM (SAS version 5) was used to compare eagle density on Besnard and Nemeiben lakes and on each lake separately (to detect changes from the activity to productivity surveys). Small sample size prohibited comparison of the eagle populations on the mid-lakes.

Aerial surveys were flown on Besnard and Nemeiben lakes (29 and 30 April 1986, and 1 May 1987) to determine the status of the breeding areas prior to the breakup of the ice and before leaf-out. Spotting some of the nests in 1986 proved difficult as it had snowed the night before our flights. A Cessna 185 was used on all flights. Boat surveys were not conducted on the mid-lakes in 1986 or 1987.

Results

In 1984 a minimum of 23 pairs initiated nests on Besnard Lake; 18 pairs successfully fledged 31 young. This compares to 14 of 21-23 attempts producing 21 young in 1986. Nemeiben Lake had three of 3-6 pairs successful in fledging 3+ young in 1984, and six of 10 pairs producing 9+ young in 1986. The mid-lakes fledged 17+ young from 11 of 12-13 active pairs in 1984 (Table 1).

TABLE 1. Numbers of nests, breeding areas and young fledged on Besnard, Nemeiben, Gull, Morning, Triveet, and Clam lakes, Saskatchewan.

Lake	Year	Total[1,2] nests	Total breeding areas	Status of breeding areas Empty	Occupied	Active	Successful (SBA/OBA %)[3]	Young fledged (YNG/OBA)[4]
Besnard								
	1984	34	25-26	1-2	24-25	23	18 (72-75)	31 (1.24-1.29)
	1986	36	31-36	10-15	24-28	21-23[5]	14 (50-58)	21 (0.75-0.875)
	1987	37	29	2	27	25	19 (70)	30+++[6] (1.11)
Nemeiben								
	1984	7	7	1-3	3-6	3-6	3 (50-100)	3+ (0.5-1.0)
	1986	11	10	0	10	10	6 (60)	9++ (0.9)
	1987	11	10	0	10	9	7 (70)	9++ (0.9)
Mid-lakes								
	1984	20	17	3-4	13	12-13	11 (85)	17++ (1.31)

[1] Total breeding areas fewer than total nests as some breeding areas have more than one nest.
[2] Range of values given as we could not determine the status of some nests.
[3] Nesting success — percentage of successful breeding areas (SBA) per occupied breeding area (OBA).
[4] Number of young fledged (YNG) per OBA.
[5] Two nests not seen on aerial survey, may have been active at that time.
[6] Unable to accurately determine the number of young + (1), ++ (2), or +++ (6) nests.

Nest success, the number of successful breeding areas (SBA) divided by the number of occupied breeding areas (OBA), on Besnard Lake in 1984 (72–75%) was almost identical to the 14-year average (73 ± 12 (mean ± 2 SD)) reported by Gerrard et al. (1983). Values for nest success on Besnard Lake in 1986 were 50-58% depending on the number counted as occupied breeding areas. Nesting success on Nemeiben Lake was 50 to 100% in 1984, and 60% in 1986. The combined nesting success on the mid-lakes in 1984 was 85%. Young fledged per occupied breeding area, a ratio used by Sprunt et al. (1973) to predict the stability of an eagle population, ranged from 0.5 to 1.31 in 1984, with 0.9 on Nemeiben Lake and 0.75-0.88 on Besnard Lake in 1986 (Table 1).

The number of eagles counted on each lake changed from the activity to the productivity surveys and differed between lakes (Table 2). Besnard Lake showed a 50% increase in the

TABLE 2. Bald Eagle population estimates, north-central Saskatchewan.

Lake	Year	Survey[2,3]	Eagles/lake Adults	Immatures	Ads&Imms	Eagles/10 km Shoreline[1] Adults	Immatures	Ads&Imms
Besnard****[4]	1984	1**[5]	47.7	18.5	65.9	1.19	0.46	1.65
	1984	2**	70.3	26.6	96.8	1.76	0.67	2.42
	1986	1	48.6	13.5	62.2	1.21	0.34	1.55
	1986	2	71.6	17.9	89.5	1.79	0.45	2.24
	1987	2	66.2	29.1	95.3	1.65	0.73	2.38
Nemeiben***	1984	1	10.7	1.9	12.6	0.26	0.05	0.31
	1984	2	22.8	4.0	26.8	0.55	0.10	0.64
	1986	1	22.5	4.1	26.5	0.54	0.10	0.64
	1986	2	24.5	2.0	26.5	0.59	0.05	0.64
	1987	2	26.4	4.9	31.3	0.66	0.12	0.78
Midlakes	1984	1	47	31.6	78.6	1.31	0.88	2.18
	1984	2	35	7.9	42.9	0.97	0.22	1.19

[1] Shoreline lengths (km) used in calcuations: Besnard (400), Nemeiben (416), mid-lakes (360).
[2] Survey 1 — May–June boat surveys, Survey 2 — July–August boat surveys.
[3] Population estimates in each survey are the average of two censuses (odd and even, see methods for more details).
[4] Population estimates for each age class significantly different ($P < 0.001$) between Besnard and Nemeiben lakes for each survey.
[5] Besnard Lake population estimates for adults and ads&imms significantly different ($P < 0.01$) between surveys 1 and 2.

number of adults and the total population from May-June to July-August in 1984 and 1986 ($P < 0.01$). Increases in the number of immatures on Besnard Lake from May-June to July-August were not significant ($P > 0.05$); however, the increase was significant ($P < 0.001$) with the inclusion of data from 1976-1978 (Gerrard, Bortolotti and Whitfield, unpublished data). The eagle population on Nemeiben Lake more than doubled from May-June to July-August in 1984 but remained essentially static in 1986 (Table 2). The mid-lakes showed a 45% decrease in their total eagle count from May-June to July-August in 1984.

Eagle populations on Besnard Lake and the mid-lakes continue to exist at previously documented levels. Annual variation in population estimates on Besnard Lake is not significant ($P > 0.05$); our July-August estimates for the mid-lakes are similar to those documented by Gerrard and Gerrard (1985). The much lower eagle density on Nemeiben Lake (Davis 1986) was confirmed by our surveys (Table 2).

Discussion

Major differences exist in Bald Eagle populations on Besnard Lake and the mid-lakes relative to Nemeiben Lake. Breeding area density is not necessarily commensurate with eagle density; Whitfield et al. (1974) found an area with high numbers of adults not associated with nests. Nemeiben Lake has fewer breeding areas combined with significantly fewer adults and immatures. Potential factors limiting or reducing eagle use on Nemeiben Lake relative to the other lakes include availability of suitable forest nesting sites, availability of a sufficient prey (fish) base, and human activities and development on the lakes.

Qualitative observations indicate that Nemeiben Lake has relatively fewer kilometers of shoreline with suitable nesting habitat than Besnard Lake. Nemeiben Lake has more small Trembling Aspen (*Populus tremuloides*), Jackpine (*Pinus banksiana*), and Black Spruce (*Picea mariana*) which are unsuitable for nesting. Even with fewer kilometers of suitable nesting habitat, Nemeiben Lake should support many more pairs than are currently present and it is unlikely that eagle density there is severely limited by lack of nesting habitat.

The Bald Eagle population on Nemeiben Lake may be limited by the availability or abundance of prey. Bortolotti (personal communication) found that fish made up 99% of the eagle's diet on Besnard Lake, with Cisco (*Coregonus artedii*) and White Sucker (*Catostomus commersoni*) the most important prey species. Available fisheries data allow comparison of the fish populations on the two lakes. The average catch per standard gang gillnet set on Besnard Lake was n = 135.7 (79.3 kg) with Cisco constituting 35.8% of the catch by number and 23.4% by weight (Chen 1974). The average catch in Nemeiben Lake was n = 90.1 (49.2 kg) with Cisco contributing 26.1% to the catch by number and 5.8% by weight (Koshinsky 1964). If fish populations have remained comparable to the time of our study, Cisco are 1.4 times as abundant and average four times heavier in Besnard Lake than in Nemeiben Lake and therefore Besnard Lake could support more eagles. Fraser et al. (1985) suggest sub-adults may move to large lakes in summer in response to greater prey availability. Nemeiben Lake experiences little or no mid-summer immigration of sub-adults and non-breeding adults, further suggesting the lake does not offer an abundance of prey to attract nonbreeding birds.

Human activities and development have been implicated in the decline of eagle populations elsewhere (Sprunt 1969) and are known to alter Bald Eagle behaviour (e.g. Stalmaster and Newman 1978; Knight and Knight 1984), although they may not have an impact on reproductive success (e.g. Fraser et al. 1985). The road to Nemeiben Lake was constructed in 1958. In 1968 an aerial survey of approximately 30-40% of the lake's shoreline revealed four breeding areas (five nests). Roughly the same length of time (10 years) has elapsed since the road went into Besnard Lake in 1973. The eagle population in 1968 was already low at Nemeiben Lake yet the latter was probably equal to or (more likely) less developed than Besnard Lake is now. Although we cannot unequivocally rule out a decline of the Nemeiben Lake population, we suggest that development per se probably is not the only causal factor for lower eagle numbers there. The Besnard Lake data suggest that significant development can occur without affecting eagle breeding. At Nemeiben Lake it may be the particular type of development, the effects of local attitudes toward eagles, or some other aspect of human activities which are adversely affecting the eagles.

The results from Besnard Lake and the mid-lakes were consistent with those from previous surveys (Gerrard et al. 1983; Gerrard and Gerrard 1985). This implies reasonable replicability of the survey method for counting eagles and nests. On the first survey we were able to find 80% of the total number of eagle nests on Besnard Lake; during the second survey we are confident that we found most of the nests on the lakes. Such consistency and reliability in detecting nests indicates that the data for all the lakes including Nemeiben Lake are reasonably precise and accurate.

Although eagle populations on Besnard Lake and the mid-lakes have remained stable, counts do exhibit seasonal variations within a given year, and some of the factors in these variations are worth emphasizing. Only one complete survey was previously conducted on the mid-lakes (in 1981) and Gerrard and Gerrard (1985) were therefore unable to determine whether eagle density was lower on the mid-lakes than Besnard Lake or if the census corresponded to a period when the population was at a low point. The 1984 data indicated that eagle density on the mid-lakes was higher than Besnard Lake early in the summer and that there was an emigration of immatures and non-breeding adults from these lakes sometime between mid-June and late July. Seasonal population changes reflect the movements of non-breeding eagles, probably in response to changes in prey availability (Fraser et al. 1985).

Reduced nesting success on Besnard Lake in 1986 may be due to natural and sampling effects. Probably many breeding attempts in 1986 failed as a result of a severe snowstorm (10 cm snow) on 28 April. Reduced eagle reproduction in the Greater Yellowstone Ecosystem (GYE) and on Besnard Lake in 1975 may have been related to severe spring weather (Gerrard and Whitfield 1979; Swenson et al. 1986). A spring weather index explained 63% of the variation in production of young in one area of the GYE (Swenson et al. 1986). Nesting success in 1984 and other years when aerial surveys were not conducted may be artificially high because the actual number of breeding attempts initiated was underestimated. Attempts should be made to identify and distinguish natural and artificial reduction in nesting success.

Another by-product of the snowstorm the day before our aerial survey was that snow on the trees reduced our success in detecting nests and eagles. The number of nests which were missed (n = 11) might have been even higher had EHD not been familiar with many of the nest locations. Whenever possible it is advisable that aerial surveys for nesting Bald Eagles be conducted in a snow-free period even if it means rescheduling flights.

Further research is clearly necessary to understand seasonal movements of non-breeding eagles and the relative contribution of the various factors (nest site availability, prey resources and human influences) limiting eagle density on Nemeiben Lake. The results could have widespread implications for understanding variations in eagle density across the boreal forest of Canada and, therefore, in managing these populations.

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Charophytes of Insular Newfoundland

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Ten taxa of charophytes (Characeae), three of *Nitella* and seven of *Chara*, are reported from insular Newfoundland. Two of these, *C. canescens* and *N. gracilis* f. *confervacea*, are first records. In addition, several forms of *C. globularis* and *C. vulgaris* not previously distinguished in Newfoundland are reported. Brief descriptions of salient features are provided and known distributions are given for all taxa. An attempt is made to include all literature citations of Newfoundland Charophytes.

Key Words: Charophytes, Characeae, *Chara, Nitella*, Newfoundland, distributions.

Charophytes (stoneworts) are common aquatic macrophytes of the fresh and brackish waters of insular Newfoundland, but to date little information exists on the species present or their distribution. Maps for North America in Wood (1967) show only one species of *Chara* and one species of *Nitella*, possibly two, occurring on the island, and varieties of these are not distinguished. The few more recent reports are either incidental to other studies (Smith 1970; Daggett and Davis 1974), are of uncertain taxonomic rank and therefore not precisely definable in terms of Wood's (1965) most recent revision (Dadswell 1970; Daggett and Davis 1974), or are not verifiable (Robertson et al. 1973; Robertson 1980). This paper reports ten taxa from collections made by the author during the years 1979-1986 and attempts to include all known documentation of charophytes from the siland of Newfoundland.

Insular Newfoundland has an impoverished flora and fauna when compared to the adjacent mainland partly due to the difficulty of transoceanic recolonization since the Wisconsin glaciation and partly due to climate, topography and soils (Mednis 1981). The cold Labrador current produces a much harsher climate than that of North American or European lands of the same latitude, while the island's maritime nature produces milder winter temperatures than those of comparable continental locations but cooler summers and a much shortened growing season (Damman 1965; Banfield 1983). Although suitable habitats exist for many terrestrial and aquatic species found on the mainland, these habitats are often limited in size and are widely scattered, thus decreasing the probability of natural introduction and dispersal.

Such is the case for freshwater marshes, brackish marshes, marl ponds and scattered, nutrient-rich water bodies, all of which may be separated by rugged mountainous country or wide expanses of peatlands or heath barrens. Charophyte species, however, appear to be readily dispersed by waterfowl and shorebirds, the spores adhering to feet and feathers or remaining viable in the feces (Proctor 1959, 1962, 1967). Insular Newfoundland lies within the migratory routes of many such bird species, and so most of the common charophyte species whose ranges extend into the Maritimes and Quebec should also have found their way to the island to establish themselves where suitable aquatic conditions exist.

About ten percent of the island consists of freshwater lakes, ponds, rivers and streams with an additional fourteen percent consisting of peatlands (Roberts 1983). Much of the peatlands is also aquatic habitat containing many small pools or flashets, some of which are suitable for charophyte growth, especially in the less acidic and more nutrient-rich fens of the west coast.

Many insular lakes lie over Precambrian rocks of low solubility, and waters are therefore generally acidic and low in dissolved substances (Jamieson 1974a, 1974b; Seabrook 1962). Most reported pH readings occur in the 6.0 to 6.9 range, but values as low as 3.03 are recorded from bog waters (Damman 1986) and as high as 8.05 from limestone areas of the west coast (Jamieson 1974a). Low phosphorous levels appear to be a major factor governing the limited productivity of most Newfoundland waters (Kerekes 1974, 1978). Some waters are also highly coloured with humic acids and are therefore less transparent and productive. When conditions of climate, substrate, and topography are considered in combination, insular Newfoundland waters present aquatic habitats unique to this latitude in North America (Davis 1973), and this may have moderated successful establishment and widespread dispersal of species that otherwise might be readily introduced from the mainland.

The study area upon which most of the present reports are based consists of that part of the island lying west of a line joining Burgeo in the south to Springdale in the north and includes the Great Northern Peninsula. Generally, only areas accessible by road have been sampled. Sporadic collections have been made in central Newfoundland, the St. John's area, and Brunette Island on the south coast.

The distribution maps included should be interpreted with caution, since the large blank areas of central Newfoundland and the Avalon Peninsula largely reflect the lack of study but to some extent may also prove in the future to reflect the more acid nature of waters over extensive bogs and barrens in this region. Even the main study area has not been sampled exhaustively and much promising aquatic habitat remains unexplored in this, the most varied and botanically interesting portion of the island.

All nomenclature used is based on or compared to the most recent monograph of the group by Wood (1965) and the accompanying iconograph by Wood and Imahori (1964). However, because the bulk of charophyte literature is based on a more traditional nomenclature and in light of more recent work that throws open to question parts of Wood's (1965) revision (Proctor 1971a, b, 1975, 1980), it seems prudent to also include the traditional synonymy for species listed.

Characteristics not discussed in this paper fall within the range of features described in Wood (1965) for these species. Voucher specimens of all taxa listed in this paper are housed as liquid preservations and/or dried sheets in the herbarium of the Sir Wilfred Grenfell College, Memorial University of Newfoundland, Corner Brook, Newfoundland. A set of herbarium sheets has been deposited with the National Museum of Natural Sciences, Ottawa (CAN). Also included on the distribution maps are specimens from the Phycological Herbarium of Memorial University, St. John's (NFLD) and from verified literature reports. Non-verifiable literature reports are distinguished on the maps. Herbarium abbreviations used are as listed in Woodland (1979).

Species Accounts

1. *Chara globularis* Thuill. em. R.D.W.

Within this triplostichous, broad species as compiled in Wood (1965), three distinct taxa are readily recognizable in Newfoundland, form *virgata*, form *globularis*, and form *aspera*. Each of these has in the past been considered a separate distinct species (Groves and Bullock-Webster 1924; Corillion 1957), and some modern authorities still prefer species status for some or all of these entities (Forsberg 1963; Langangen 1974; Moore 1979; Krause 1983). Proctor (1971a, 1975) supports the latter view with experimental breeding studies showing that considerable reproductive isolation exists among members of the *C. globularis* complex. The Newfoundland taxa encountered to date in the *C. globularis* group are morphologically quite distinct when sufficient vigorous material is examined. It is therefore important that future reports be precisely defined using either Wood's (1965) forms and/or the traditional corresponding species synonyms. Both of these are given in the following accounts.

The North American distribution map in Wood (1967) shows *C. globularis* occurring throughout the island; however, subspecific taxa are not distinguished. Figure 1 illustrates the known distribution of the three taxa. Daggett and Davis (1974) report *C. globularis* from a bog pond on the Avalon Peninsula, but no specimens are available to determine its subspecific identity.

a. *Chara globularis* f. *virgata* (Kütz.) R.D.W.
(= *C. delicatula* Agardh)

This is the most common and ubiquitous *Chara* on the island. It is monoecious and strongly tylacanthous with very regular cortication. The upper row of stipulodes are elongated, especially in young vigorous portions of the axes. Large amorphous bulbils are found at anchoring nodes in some collections. Coronula cells are connivent and often characteristically curving towards the tip. It has the most pungent sulphurous odour of all Newfoundland Charophytes and can usually be recognized by smell alone. Figure 1 indicates a fairly uniform distribution in areas sampled and it can therefore be expected to occur commonly throughout the island.

Form *virgata* can tolerate a broader range of environmental conditions than most *Chara* (Olsen 1944; Forsberg 1965; Langangen 1974). In Newfoundland it is found in soft acid waters in association with *Nitella flexilis* or in calcium-rich waters in association with *C. vulgaris* where it may become moderately encrusted.

b. *Chara globularis* f. *globularis* Thuill.
(=*C. fragilis* Desvaux)

This monoecious *Chara* is isostichous and very smooth with globular to obscure spine cells, stipulodes and posterior bract cells. Anterior bract cells and bracteoles are usually shorter than mature oogonia. Coronula cells are connivent, but straight-sided and not curving towards the tip as is characteristic in f. *virgata*.

This form, appearing to be much less common than f. *virgata*, was found at only five collection sites, but these are distributed throughout the study area (Figure 1). Like f. *virgata* it is found growing in acid waters in association with dioecious and monoecious forms of *Nitella flexilis* where it produces no evident encrustation, and also in calcium rich waters with heavily encrusted *C. vulgaris*, where it develops light to moderately encrusted axes. It is also commonly found growing in association with the tylacanthous form *virgata*.

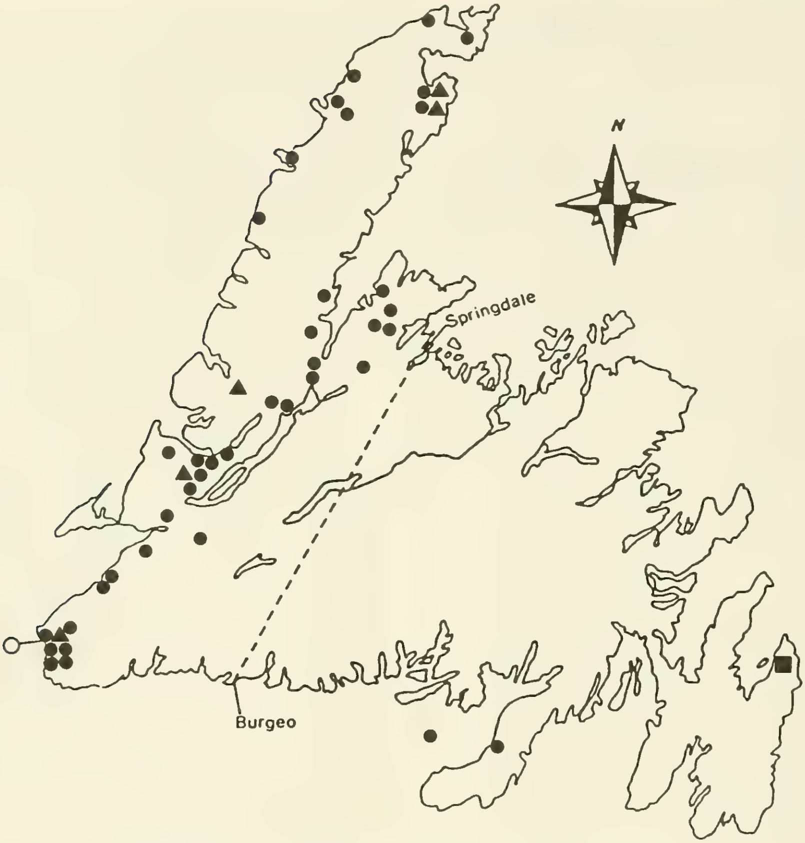

FIGURE 1. Distribution of *C. globularis* Thuill. in insular Newfoundland.
● = f. *virgata* ▲ = f. *globularis*
○ = f. *aspera* ■ = f. unknown

c. *Chara globularis* f. *aspera* (Deth. ex. Willd.) R.D.W.
(=*C. aspera* Deth. ex. Willd.)

This dioecious *Chara* is considered by many to be a distinct species or species complex rather than a form of *C. globularis* (Forsberg 1963; Croy 1982; Krause 1983), and Proctor (1971a) has shown that it is reproductively isolated from other members of the *Chara globularis* complex.

The Newfoundland population examined is weakly tylacanthous to isostichous with a regular to irregular axial cortex. Stipulodes and spine cells are usually long and well developed with somewhat inflated bases. Each coronula cell tapers to a point and these tips are divergent. Characteristic white spherical bulbils are common on rhizoids, singly or in clusters.

Robinson (1906) reports *C. aspera* from Newfoundland, but a precise location could not be determined. In the present study this *Chara* was only collected at one site, in a marsh were the Grand Codroy River flows into its estuary at Doyles, Newfoundland (Figure 1) [Canadian Topographic Map 11-0/14, Universal Transverse Mercator (U.T.M.) Military Grid Reference 343998]. The water remains fresh in the marsh, but a slight influence of tides is felt here, and salinity shows considerable fluctuation above that of the incoming river water. Both Olsen (1944) and Langangen (1974) indicate that *C. aspera* can be found in waters of low salinity as well as those distinctly brackish.

Extensive mats of f. *aspera* occur in shallow water (20-40 cm) with a thick organic mud substrate near the southern shores of this marsh. The mats consist almost entirely of female plants; males are encountered infrequently. Even late in the season (21 October 1986) orange mature oogonia were not overly abundant and no mature oospores could be found. Associated with f. *aspera* in other deeper portions of this marsh (to 2 m) were f. *virgata*, f. *globularis*, both the monoecious and the dioecious *Nitella flexilis*, and *Nitella gracilis* f. *confervacea*.

2. *Chara canescens* Desv. & Lois. in Lois.

This species has not been previously reported from insular Newfoundland. Only one site is known to the author (Figure 2), a shallow brackish lagoon near the mouth of the St. Georges River [Canadian Topographical Map 12B/8, U.T.M. 945705]. The lagoon is now separated from the St. Georges River estuary by two highway embankments and a railway embankment, but still receives some water exchange through culverts. It drains surrounding peatlands, and, at its closest, it is separated from the Gulf of St. Lawrence by only 100 meters of semi-stabilized sand dunes. Readings taken with a Myron Model 512T5 DS Meter show the lagoon water to have a range between 4600-5050 ppm dissolved solids. *C. canescens* is reported as a species of brackish coastal distribution or inland saline waters (Olsen 1944; Corillion 1957; Langangen 1974).

C. canescens is haplostichous and the axes have a bristly appearance due to clusters or elongated spine cells. The St. Georges population is dioecious with no male plants apparent. This species is reported to produce viable spores parthenogenically (Allen 1950; Corillion 1957), the only charophyte known to have this ability. Mature oogonia of this population are usually colorless (white) or at most only a faint orange, the oospores becoming black at maturity.

Wood (1965) describes two forms of this species based mainly on plant size and the number of oospore striae. The Newfoundland plants are small, to 12.0 cm in length with 9-13 oospore striae, and are therefore of the typical f. *canescens.*

3. *Chara vulgaris* L. em. R.D.W.

Two distinct species of this diplostichous, monoecious *Chara, C. contraria* and *C. vulgaris*, have been recognized by European and North American authorities (Robinson 1906; Corillion 1957). The principal distinction between the two is axis cortication, *C. contraria* being tylacanthous and *C. vulgaris* aulacanthous. Wood (1965) does

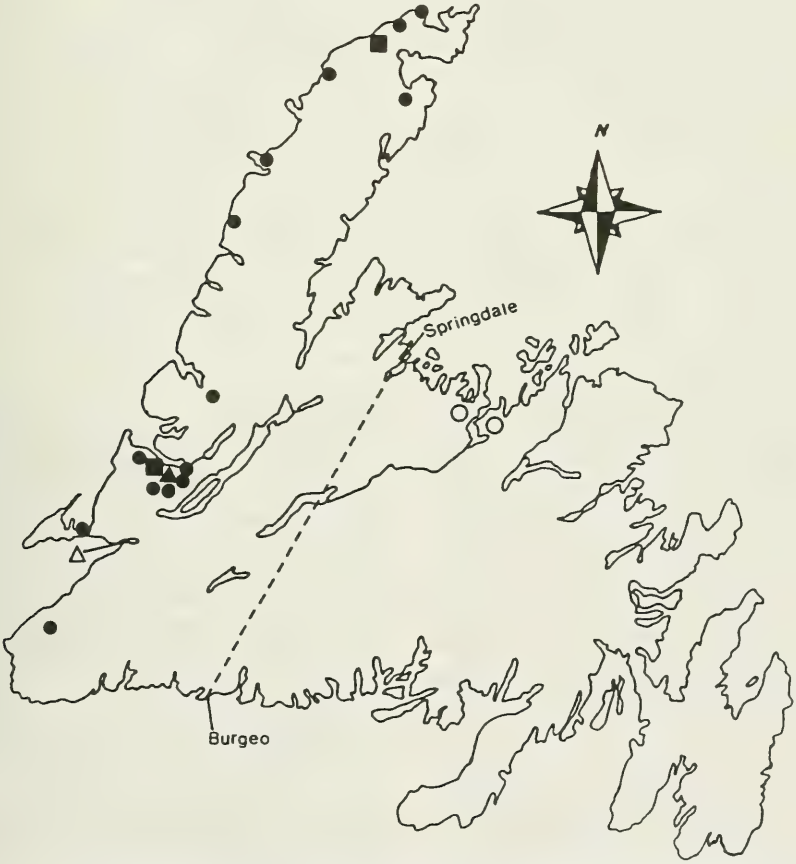

FIGURE 2. Distribution of *C. vulgaris* L. and *D. canescens* Desv. and Lois. in Lois. in insular Newfoundland.
● = f. *contraria* ▲ = f. *vulgaris*
■ = v. inconnexa ○ = *C. foetida* △ = *C. canescens*

not consider the cortication difference to be significant in this group and has designated *C. contraria* as a conspecific form of *C. vulgaris*. However, Grant and Proctor (1972) have shown, on the basis of experimental work, that the two are largely reproductively isolated even though morphological distinction may sometimes be difficult.

The distribution map of *C. vulgaris* in Wood (1967) does not include insular Newfoundland, but several reports of *C. foetida* Braun, a synonym of aulacanthous *C. vulgaris* L., exist (Pollett and Meades 1970; Robertson et al. 1973). No supporting specimens, however, are known to exist for these reports.

a. *Chara vulgaris* f. *contraria* (A.Br. ex. Kütz.) R.D.W.
(= *C. contraria* A.Br. ex. Kütz.)

Almost all Newfoundland specimens collected are distinctly tylacanthous and conform to other suggested distinctions used by authors to separate *C. contraria* from *C. vulgaris*, such as black oospores, short anterior bract cells (Grant and Proctor 1972), and less regular stipulodes (Allen 1950). Axes are generally from 10 to 30 cm in length with branchlets 10 to 20 mm long, but very small forms with axes 4 to 8 cm and branchlets 2 to 4 mm are not uncommon. In detailed morphology, however, these smaller plants conform to this variety quite well.

Other variations encountered in a few collections assigned to this taxon were mainly of imperfect branchlet cortication, but the bulk of the material conformed well to f. *contraria*. One collection also exhibited stipulodes extended away from the node, each pair on the end of an elongated cell, and one collection exhibited infrequent bifid ecorticate end cells on some branchlets.

C. contraria and *C. vulgaris* are known to be species which preferentially grow in alkaline waters of high calcium content (Olsen 1944; Langangen 1974). Figure 2 shows the distribution of f. *contraria* in the study area. Most collections are from regions of limestone and these all show moderate to heavy encrustation, reaching maximum encrustation in the marl ponds of the Corner Brook south area. The one collection showing no encrustation came from a pond in peridotite rock, a rock high in magnesium but low in calcium and producing a neutral to basic pH (Roberts 1980).

b. *Chara vulgaris* f. *vulgaris* L. (= *C. foetida* Braun)

Only one collection of aulacanthous material was made from a marl stream near Corner Brook (Figure 2). Except for cortication and longer anterior bract cells, the highly encrusted specimens resemble f. *contraria*. *C. foetida*, reported by Robertson et al. (1973), is recorded separately because precise map co-ordinates are not given and no material is available for verification.

c. *Chara vulgaris* variety *inconnexa* (T.F.A.) R.D.W.
(= *C. inconnexa* T.F. Allen)

Included here are two widely separated collections (Figure 2) of small plants with axes of 4 to 8 cm and branchlet lengths of 3 to 8 mm, similar in most respects to f. *contraria*, but with ecorticate lower axis internodes and with branchlet cortication varying from regular to partial to completely ecorticate. Often gametangia are located at corticated branchlet nodes and occasionally at ecorticate or partially ecorticate nodes. Stipulodes vary from irregular with the uppermost more prominent to regular with both rows equal. Because of lack of consistency of characteristics within either collection, it is probably not meaningful to assign these specimens to one of Wood's (1965) six forms of v. *inconnexa*.

4. *Nitella flexilis* (L.) C.A. Ag. em. R.D.W.
(= *N. flexilis* (L.) Ag. and *N. opaca Ag.)*

Nitella flexilis is mainly distinguished by once furcate branchlets, one-celled dactyls, and by oospore size. This species, as recognized by Wood (1965), includes both the dioecious *N. opaca* Ag. and the monoecious *N. flexilis* (L.) Ag. of previous authors (Wood 1948; Allen 1954; Corillion 1957). They are considered conspecific by Wood (1965), with the suggestion that the monoecious/dioecious condition is not a significant characteristic in this group. This view is also supported by Moore (1979) because *N. opaca* and *N. flexilis* cannot be distinguished by morphological means without the presence of gametangia. On the other hand, McCracken et al. (1966) and Proctor (1971b, 1975, 1980) have shown that the monoecious/dioecious condition is an important taxonomic character in the genus *Chara* and Sawa (1965) indicates that this may also be the case in *Nitella*.

Both monoecious and dioecious specimens are common on the island and most collections can readily be distinguished. However, some collections which appeared to be dioecious with only oogonia present were found to be monoecious upon careful examination, the antheridia only occurring very infrequently. At two sites monoecious and dioecious plants were found growing together in the same general area. Figure 3 records the distribution of monoecious, dioecious and non-fruiting plants separately.

Wood (1965) separates *N. flexilis* into v. *flexilis* and v. *spanioclema*, which produces some 2-furcate branchlets. In most of the present collections the 2-furcate condition can be found, occurring infrequently, but in a few collections becoming reasonably frequent. However, the

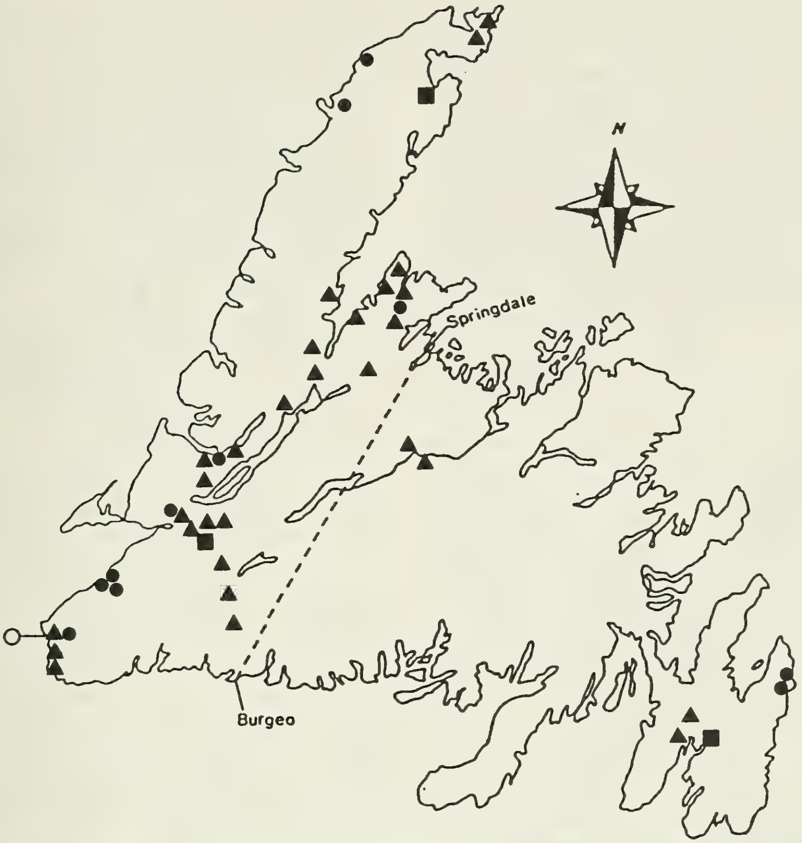

Figure 3. Distribution of *N. flexilis* (L.) Ag. and *N. gracilis* f. *confervacea* Bréb. in insular Newfoundland.

● = monoecious *N. flexilis*
▲ = dioecious *N. opaca*
■ = non-fruiting *N. flexilis*
○ = *N. gracilis* f. *convervacea*

plants do not otherwise correspond to the descriptions of v. *spanioclema* and all collections are considered to be v. *flexilis*.

Two of Wood's (1965) forms are represented in the present study in addition to the most common f. *flexilis*. Slender, lax plants with long dactyls and with branchlets much longer than axial internodes may be considered f. *longifolia*. Those with fertile whorls compacted into head-like units may be considered f. *nidifica*. Wood (1965) does not attach much significance to these forms, as they appear to fall within the normal variation range of the species and the degree to which environment and/or genetics are involved in their expression is not clear.

The *N. flexilis* complex is one of the most cosmopolitan of this genus and one with the broadest ecological amplitude (Olsen 1944; Corillion 1957; Langangen 1974). The present study shows it to be widespread and common in ponds and streams throughout the island. It has commonly been found in the same general locations as *C. globularis* f. *virgata*, often in acid waters, but also sometimes in alkaline, calcium-rich waters in association with f. *virgata* and *C. vulgaris* f. *contraria*.

Previous reports of dioecious collections occur from the Exploits River in central Newfoundland (Wood 1965), from a bog pond on the Avalon Peninsula (Smith 1970), and from a shallow pool of a sloping fen near North Harbour on the Avalon Peninsula (Todd Howell, personal communication and specimens). These three reports are included on the distribution map, Figure 3.

5. *Nitella gracilis* (Sm.) Ag., f. *confervacea* Bréb., em. R.D.W.
(= *N. batrachosperma* Braun, = *N. Nordstedtiana* Groves, H. & J. = *N. confervacea* A. Br.)

This *Nitella* has been located only once (Figure 3) in a marsh of the upper estuary end of the Grand

Codroy River at Doyles [Topographic Map 11-0/14, U.T.M. 340999]. The plants were growing on a mud bottom amongst other vegetation in 1 to 1.5 m of water in the same general conditions as described for *C. globularis* f. *aspera*. Wood (1948) only records this taxon from Massachusetts, Michigan, Minnesota and Nebraska in North America and his distribution map (Wood 1967) does not include insular Newfoundland. Throughout its European and North American range, f. *confervacea* is considered rare; however, because of its miniature stature and its tendency to grow in deeper waters, two factors which would limit discovery, it may be more common than records indicate (Allen 1950; 1954; Groves and Bullock-Webster 1920).

Newfoundland specimens are tiny delicate plants with axes less than 3 cm in length. The uppermost 3-4 branchlet whorls are compact, forming large terminal clumps or loose heads up to 2 mm in diameter and having a hint of mucus. Branchlets of these terminal whorls are short with dactyls often only 200-400 μm long. Branchlets are usually 2-furcate and gametangia are common at the first node. The end cell of the two-celled dactyls is tiny, often almost a mucronate tip.

On the collection date 20 July 1982, apparently mature antheridia and oogonia were present on this monoecious *Nitella*, but mature oospores had not yet developed. However, sufficient germinated oospore jackets still attached to their plants were present to determine membrane decoration. The golden-brown membranes are conspicuously granulate, sometimes becoming weakly reticulate, but never conspicuously coarsely reticulate like those of *N. tenuissima*, with which this taxon may sometimes be confused. Oospores of this sample have six to seven fossae and have a length of 330-370 μm and a width of 200-300 μm.

Doubtful Records

One report on the peatland flora of our region (Robertson 1980) lists several species of Charophytes as occurring: *Chara braunii* Gm., *Chara foetida* Braun, *Chara intermedia* A. Br., *Nitella gracilis* (J. E. Smith) Agardh, and *Nitella flexilis* (L.) Agardh. The author simply lists these species without providing source references and he does not differentiate insular Newfoundland from Labrador or the French islands of St. Pierre and Miquelon.

No known specimens supporting the above reported occurrence of *C. braunii*, *C. intermedia* and *N. gracilis* are known to exist. It is possible that *C. braunii* may occur on the island, as its range extends into Quebec and Nova Scotia (Wood 1967). *C. intermedia* (= *C. hispida* form *intermedia* (A.Br.) R.D.W.), however, is a European species not known from North America (Wood 1965). Until the presence of these two species can be confirmed, they should not be considered part of the insular Newfoundland flora.

Identification of Newfoundland Taxa

Charophytes have a unique morphology and therefore a terminology specific for this group has developed. Accurate identification requires a thorough understanding of their structure and a recognition that considerable variation exists within many taxa. However, most Newfoundland taxa are fairly distinct and may be readily identified by the following simple key.

A number of good illustrated reference sources are available and are useful in identification of all the major taxa known to occur in insular Newfoundland. Some of the best of these, especially for the novice, are Moore (1986), Allen (1950), and Groves and Bullock-Webster (1920, 1924). The included key and synopsis should be used in conjunction with the glossary, illustrations and explanations in these or other sources. Wood's (1965) monograph must be used as the ultimate reference, but it assumes a thorough grounding in charophyte structure and taxonomy. The small booklet, *Charophytes of North America* (Wood 1967) is also of some use, especially the keys, but does not clearly explain terminology nor adequately distinguish North American varieties.

Chara vulgaris is an extremely variable group and it may be that other varieties and forms will be encountered in the future. Wood's (1965) keys should be consulted in case of doubt.

Key to Newfoundland Taxa

1a. Cortical cells preseent on the main axes, coronula of 5 cells .... *Chara* 2
1b. Axes without cortication, coronula of 10 cells .... *Nitella* 8
    2a. Axial cortex composed only of primary rows of cells, e.g. all rows of cortical cells containing spine cells (haplostichous) ...... *C. canescens*
    2b. Axial cortex of primary rows with spine cells alternating with one or two secondary rows without spine cells 3
3a. Axial cortex with each primary row of cortical cells alternating with a secondary row (diplostichous): .... *C. vulgaris* 4
3b. Axial cortex having two secondary rows alternating with each primary row (triplostichous): *C. globularis* 6
    4a. Branchlets ecorticated, partially corticated, or irregularly corticated; axial cortex irregular or partially absent ..... *C. vulgaris* var. *inconnexa*

4b. Branchlets with normal cortication; axial cortex normal 5
5a. Secondary axial cortical cells more prominent than the cells of the primary rows (aulacanthous): *C. vulgaris* f. *vulgaris*
5b. Primary axial cortical cells more prominent than cells of the secondary rows (tylacanthous): *C. vulgaris* f. *contraria*
  6a. Plants dioecious, tips of coronula cells divergent: *C. globularis* f. *aspera*
  6b. Plants monoecious, tips of coronula cells connivent 7
7a. Primary axial cortical cells much more prominent than cells of the secondary rows (tylacanthous), upper row of stipulodes elongate .... *C. globularis* f. *virgata*
7b. Cortical cells of primary and secondary rows equal in size (isostichous), stipulodes globular to obscure .... *C. globularis* f. *globularis*
  8a. Unbranched end segments of branchlets (dactyls) of one cell .... *N. flexilis*
  8b. Dactyls two-celled, end cell tiny, pointed .... *N. gracilis* f. *confervacea*

The following synopsis of insular Newfoundland taxa uses the nomenclature of Wood (1965).

Chara globularis var. *globularis* f. *globularis* Thuill.
Chara globularis var. *virgata* f. *virgata* (Kütz.) R.D.W.
Chara globularis var. *aspera* f. *aspera* (Deth. ex. Willd.) R.D.W.
Chara canescens Desv. & Lois. in Lois.
Chara vulgaris var. *vulgaris* f. *vulgaris* L.
Chara vulgaris var. *vulgaris* f. *contraria* (A.Br. ex. Kütz.) R.D.W.
Chara vulgaris var. *inconnexa* (T.F.A.) R.D.W.
Nitella flexilis (L.) C.A. Ag. [including *N. opaca* Ag.]
Nitella gracilis var. *confervacea* f. *confervacea* Bréb.

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Territory Sizes of Song Sparrows, *Melospiza melodia*, in Rural and Suburban Habitats

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DeGraaf, Richard M. 1989. Territory sizes of Song Sparrows, *Melospiza melodia*, in rural and suburban habitats. Canadian Field-Naturalist 103(1): 43–47.

Territory sizes of Song Sparrows (*Melospiza melodia*) reported for several habitats suggest that territory size may vary with habitat type or structure. Sizes of 10 rural and 10 suburban Song Sparrow territories studied in Amherst, Massachusetts, were not significantly different during prenesting and nest-building stages. Shrub density and number of conspecific males together accounted for 51 per cent of the variation in territory size. Separate analyses of rural and suburban territory sizes would have led to a different, unjustified, conclusion that habitat features were more useful in explaining territory size than numbers of adjacent conspecific territorial males.

Key Words: Song Sparrows, *Melospiza melodia*, territory size, habitat.

Despite increasing interest in the effects of urbanization on bird populations, territorial requirements of birds in rural and suburban habitats have not been compared for any North American species. Factors involved in territory selection and size are poorly understood. Territory size may reflect habitat quality; two territory characteristics are important to reproductive success: availability of nesting substrates which provide cover for adults, the nest and young (Willson 1966; Holm 1973) and abundance of nestling food supply (Verner and Engelsen 1970; Willson 1966). Territory size within a species varies with population density in a homogeneous, saturated habitat (Nice 1941). Territory size also varies among individuals within a species (Wiens 1973), and territories of individuals vary with nesting phenology; Stenger and Falls (1959) and Stephanski (1967) reported that territory size in other species tends to decrease markedly after nest building is complete.

Brown (1969) reviewed the general relationship of territorial behavior to population regulation in birds, and Tompa (1962) discussed territoriality as the main factor controlling the sizes of local Song Sparrow populations. Wiens (1969) located sample sites within territories to characterize the territories. James (1971) studied species-specific attributes of avian habitats. The effects of habitat factors on the size and configuration of the occupied areas are less well known and have not been recently addressed (Stenger 1958).

Territory sizes of Song Sparrows have been reported for several habitats. Nice (1943) reported an average size of 0.27 ha in central Ohio fields, open woods, and bluffs (range 0.2 to 0.61 ha). Beer et al. (1956) found island territories as small as 0.02 ha in Minnesota, and Swedberg (1957) found an average size of 0.08 ha on an island in Minnesota. Suthers (1960) reported that shoreline territories in Minnesota had an average size of 0.19 ha (range 0.13 to 0.28 ha). These studies suggest that Song Sparrow territory size varies at different points in its range and with habitat. Such variation may be related to differences in habitat quality in that larger territories may be required in poorer habitats to include needed resources.

The present study was conducted to determine whether Song Sparrow (*Melospiza melodia*) territory size varied between suburban and rural habitats and to investigate the variability in territory size that might be attributable to either adjacent conspecific territorial males or to physical features of the territories themselves.

Methods

I studied territories of 20 randomly selected pairs of Song Sparrows in the immediate prenesting and nest-building stage between 25 May and 5 June 1972 in Amherst, Massachusetts (42° 22′ N, 72° 30′ W). Ten were located in rural areas and 10 were in suburbs. Rural territories were in agricultural areas along country roads with scattered houses; no side or backyards abutted one another. Minimum area of house lots was approximately 1.0 ha. Suburban territories were in residential areas where streets were in grid patterns and yards adjoined. Maximum area of residential lots was 0.4 ha.

I used Odum and Kuenzler's (1955) method of measuring maximum territory size. When males were seen to have attracted mates and nesting was imminent (as determined by the birds' picking at or holding nesting material), each territory was mapped by triangulation with a plane table and alidade. As many vegetation features and singing perches as possible were mapped as points of reference. All territory maps were of equal scale to facilitate area calculations.

Male birds were observed continuously for periods of 1 to 3 hours between 0530 to 0830 (EDT) on clear, calm days; their locations were observed and plotted at approximately 5-min intervals on the field maps. After each series of 10 observations, the outermost points were connected, and the area of the resultant polygon was measured with a compensating polar planimeter; two determinations were averaged to determine the area. As the number of locations plotted increased, the area of the polygon increased, with a point being reached where additional locations resulted in little or no increase in polygon area. I ceased plotting a bird's locations when each additional observed location produced an increase in area of less than 1 percent. Use of this end-point for each territory results in a comparable measure of its size. Odum and Kuenzler (1955) recommended the use of this arbitrary end-point because it is practical, represents a point of diminishing returns, and is independent of the total number of observed locations or size of the territory.

After each territory had been mapped, two half-hour observations of each male were made on subsequent days. In no case did a bird show evidence of having extended its territory beyond that which had been measured.

The variables measured in each territory were number of adjacent territorial male Song Sparrows, area of herbaceous (weedy) vegetation and lawn, number and volume of shrubs, number of shrub stems, and lengths of hedges, walls, and fences at least 0.5 m in height on the perimeter of the territory. Measurements were standardized by dividing by the territory area to express them on a per-hectare basis. The areas of lawn and weedy vegetation were calculated as the sums of the areas of convenient rectangles or triangles. Shrub volumes were obtained by visualizing each shrub as a rectangular prism and recording its length, width and height.

To estimate the relationship between territory size and these variables, a linear model was formulated:

$Y_i = a_1 + b_1 X_{1i} + \ldots + b_7 X_{7i} + e_i$, where
Y_i denotes territory size for the ith sparrow (ha).
X_{1i} = 1 if rural, 0 if suburban.
X_{2i} = number of conspecific males adjacent to the ith sparrow.
X_{3i} = number of shrub stems per ha.
X_{4i} = number of shrubs per ha.
X_{5i} = volume of shrubs in m^3 per ha.
X_{6i} = area of grass, herbs in m^2 per ha.
X_{7i} = total length (m) of fences, hedges on perimeter.
e_i is a stochastic error term,

and estimated the effects (b's) using Ordinary Least Squares procedures.

Results

Territory sizes of rural and suburban Song Sparrows, compared by *t* test, were not significantly different, though the range was greater in the suburban habitat. Rural territory size was significantly correlated with herbaceous (weedy) vegetation area; suburban territory size was significantly correlated with the number of adjacent territorial males, shrub density, and shrub crown volume per hectare (Table 1). Because territory size did not vary significantly by habitat type, territories were pooled to examine the relative effects of habitat structure and numbers of conspecific males on territory size. For this analysis, suburban "lawn area" and rural "weedy area" were considered together as "grass area." The

TABLE 1. Means and correlations between components and sizes of 10 rural and 10 suburban Song Sparrow (*Melospiza melodia*) territories, Amherst, Massachusetts.

	Rural			Suburban		
Variable	$\bar{x}$	S.E.	r	$\bar{x}$	S.E.	r
Size (ha)	0.21	0.03		0.26	0.04	
Adjacent conspecific males (number)	1.9	0.35	0.49	1.3	0.22	0.60
Shrubs						
Stems (100/ha)	9.5	3.79	0.30	4	0.32	0.31
Number (100/ha)	3	0.63	−0.34	2.2	0.03	0.94*
Volume (100 m^3/ha)	65	19.92	0.28	34.3	6.29	0.73*
Lawn area (100 m^2/ha)				5.4	1.04	0.37
Weed area (100 m^2/ha)	6.7	1.17	0.91*			
Perimeter of hedge, fence, wall (100 m)	1.0	0.16	0.22	1.1	0.16	0.58

*$P < 0.05$.

TABLE 2. Correlation between variables measured on 10 rural and 10 suburban Song Sparrow territories.

	Conspecific males	Number of stems	Number of shrubs	Volume of shrubs	Grass area
Conspecific Males					
Number of Stems	0.04				
Number of Shrubs	–0.04	0.72*			
Volume of shrubs	–0.04	0.79*	0.80*		
Grass area	0.10	0.10	0.03	–0.02	
Hedges	0.12	–0.17	0.07	–0.15	0.04

* $P < 0.05$.

seven independent variables included number of adjacent territorial males, grass area, perimeter, and three measures of shrub cover: number, number of stems, and volume, and habitat type (rural/suburban), entered as a dummy variable.

Prior to regression analyses (Ordinary Least Squares), a test of constant variance (Goldfeld and Quandt 1965) in territory size was conducted and was not significant. Intercorrelations between the three shrub variables exist (Table 2). Thus, the regression that used all variables resulted in no habitat variables being significant. But central to the study was the identification, if possible, of the specific shrub characteristics that were important.

Successive analyses deleting variables singly or in groups showed that, when included, number of adjacent conspecific males was always a significant variable, but among the vegetative or structural variables, number of shrubs was the only significant variable. This was so only when other measures of shrub cover were not entered in the analysis, thus removing the effects of intercorrelated habitat variables. Numbers of conspecific males and of shrubs (and three nonsignificant variables) together accounted for 51 percent of Song Sparrow territory size (Model 8, Table 3). Standard errors were lower in this model, also. Of course, when one resorts to exploratory data analysis as in the present situation, it is not proper to regard *t* statistics as exact. The ratios of coefficient to standard errors remain useful indicators of importance, however.

Even though territory size did not differ significantly between habitat types, a brief examination of habitat relationships in each type sheds light on Song Sparrow habitat associations. The area of herbaceous vegetation (tall weeds, grasses, annuals) per hectare was significantly

TABLE 3. Results of regression (Ordinary Least Squares) analyses of habitat type, conspecific males, and habitat structure on size of 20 Song Sparrow territories in Amherst, Massachusetts. Standard errors given in parentheses.

				Shrub					
Model	a_1	R/S b_1	Males b_2	Number of stems b_3	Number b_4	Volume b_5	Grass area b_6	Perimeter b_7	R^2
1	404.0233	22.4067	–72.6362*	0.0097	–0.2744	–0.0029	0.0060	–0.1440	0.52
		(54.6676)	(27.7868)	(0.0486)	(0.2496)	(0.0099)	(0.0072)	(0.5440)	
2	400.2246	21.1308	–72.1361*	0.0030	–0.3137		0.0064	–0.1149	0.51
		(54.6826)	(27.8310)	(0.0429)	(0.2105)		(0.0071)	(0.5366)	
3	386.4894	10.0168	–67.3271*	–0.0050		–0.0088	0.0064	–0.3658	0.47
		(56.1215)	(28.7084)	(0.0491)		(0.0088)	(0.0075)	(0.5310)	
4	387.1703	10.0456	–67.6808*			–0.0095	0.0062	–0.3595	0.47
		(56.1447)	(28.069)			(0.0056)	(0.0075)(	(0.5266)	
5	359.2225	–3.1674	–61.8788*	–0.0432			0.0079	–0.3772	0.42
		(56.8223)	(29.3568)	(0.0323)			(0.0076)	(0.5518)	
6	366.9725	–14.3629	–62.1350*					–0.2288	0.29
		(59.0760)	(32.4116)					0.6020	
7	268.1678			–0.0046	–0.2481	–0.0002	0.0068		0.20
				(0.0607)	(0.2932)	(0.0125)	(0.0090)		
8	399.8816	21.0304	–71.8416*		–0.3032*		0.0064	–0.1276	0.51
		(54.6746)	(27.5123)		(0.1458)		(0.0070)	(0.5044)	

* $P < 0.05$.

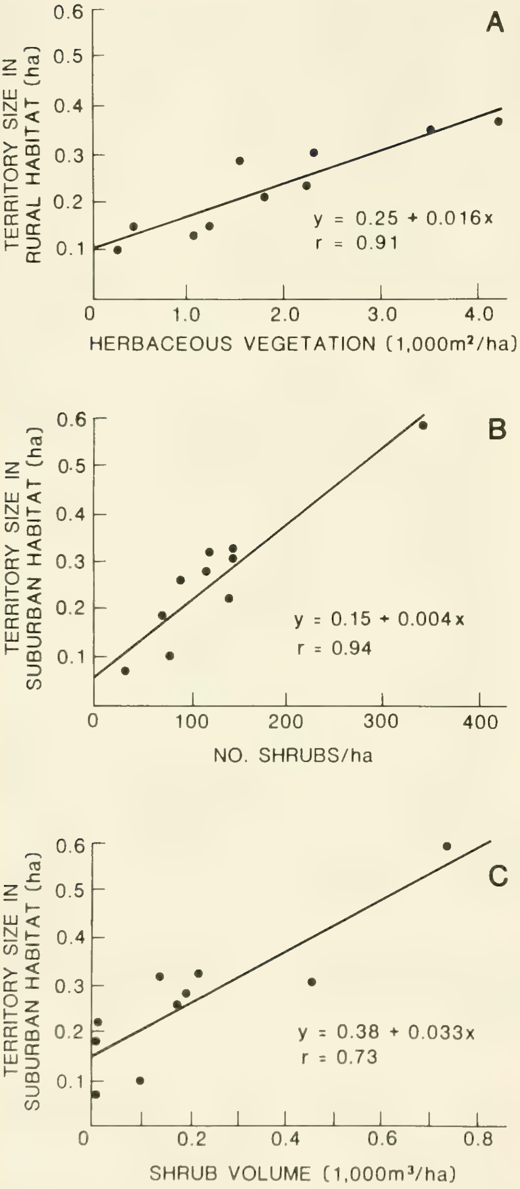

FIGURE 1. Simple regression analyses of habitat variables on Song Sparrow territory size in Amherst, Massachusetts: herbaceous area in rural habitat (A); shrub density and volume in suburban habitats (B and C, respectively).

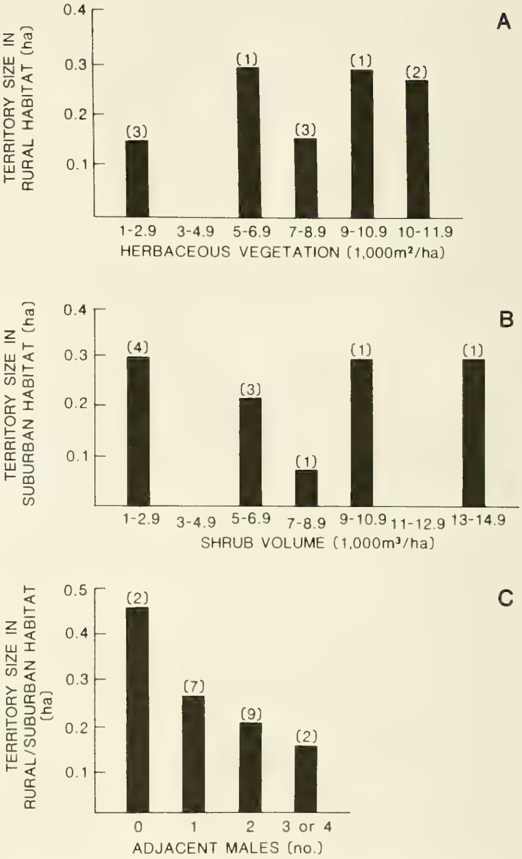

FIGURE 2. Relationships of herbaceous vegetation in rural habitat (A), shrub volume in suburban habitat (B), and number of conspecific males (C) in both habitats, to Song Sparrow territory size.

related to rural territory size (Table 1). In the suburban habitat, territory size was positively correlated with the amount of shrub cover within the territory; both shrub density and crown volume per hectare were directly related to territory size. In separate simple regression analyses, the number of shrubs accounted for more variability in territory size than did shrub volume (Figure 1).

Tall weedy rural vegetation and suburban shrubs likely meet the same needs. Positive correlations with territory size in each case suggest a similarity — if not in form, then in use or function (e.g. song perch, nest substrate, cover). The positive correlation with herbaceous vegetation area may reflect a requirement for some degree of habitat "openness", but more likely a need to establish larger territories in more open areas to include enough of the shrub components.

In a study of territory and mating success of the Field Sparrow (*Spizella pusilla*), Best (1977) found that males with larger territories mated more frequently, and that territory size was correlated positively with coverages of several grasses and associated plants. Preferred territories of Vesper Sparrows (*Pooecetes gramineus*) contained more shrub groups, perhaps a response to food availability (Best and Rodenhouse 1984). Significant differences in vegetation structure surrounding successful and unsuccessful Vesper Sparrow nests have been reported; vertical vegetation density at the nest site was positively correlated with successful nests (Wray and Whitmore 1979).

All Song Sparrow territories contained shrub densities of at least 70/ha. Those data suggested that, after the basic habitat requirements were fulfilled, Song Sparrow territory size was smallest where herbaceous vegetation and shrub cover were relatively low and that territories not bordered by other territories were in marginal, but acceptable, habitat that had higher than average biomass of either shrubs or herbs (Figure 2).

The number of shrubs *per territory* was not correlated with territory size. This is as expected; a response to shrub (or song perch) density would tend to yield a territory of sufficient suitability or area. A response merely to numbers, where they were clumped, would not. Although territory sizes were similar in rural and suburban habitats, the relationship between territory size and habitat varied somewhat.

Analyzing relationships by habitat type separately would lead to quite different conclusions than those resulting from pooled data. Separate analyses showed territory size to be a function of suburban shrub cover and rural weedy vegetation. The positive regression coefficients of those relationships may reflect the requirement of some degree of "openness" in the territory, because territory size was larger when both shrub numbers and shrub volume per hectare were greater. Thus habitats composed of all shrubs probably are marginal for the Song Sparrow as are ones of all herbaceous vegetation.

Number of adjacent conspecific males was not a significant variable in separate analyses of rural and suburban territories, implying that habitat features or vegetation structure are more useful in explaining territory size than are numbers of adjacent conspecific males or, perhaps, than population density. But separate analyses are not justified because territory size did not differ by habitat type. Pooling the data led to the conclusion that both numbers of adjacent conspecific males and habitat structure, in this case shrub density, together strongly influenced Song Sparrow territory size. This is a much more likely situation, i.e. habitat suitability, as expressed through territory size, is a function of population density and habitat structure.

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Feeding Strategies of Brook Trout, *Salvelinus fontinalis,* and Juvenile Atlantic Salmon, *Salmo salar*, in a Newfoundland River

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Stomach contents of sympatric populations of Brook Trout (*Salvelinus fontinalis*) and juvenile Atlantic Salmon (*Salmo salar*) from Wings Brook, Terra Nova National Park, Newfoundland, were analyzed to determine inter- and intra-specific differences in relative proportions of ingested prey and the relative degree of feeding selectivity. Salmon ingested more prey of aquatic origin than did trout. Large salmon parr fed upon terrestrial prey more frequently than did salmon underyearlings and yearlings. Large fish (salmon > 8.9 cm; trout > 6.0 cm) had greater monthly diet overlap than did small fish. All size classes of trout showed a more similar seasonal diet than did salmon size classes. Wider monthly breadth of diet was observed for salmon. Correlations between food length and gape were low for both species. We concluded that inter-specific competition for food was more severe between large parr and Brook Trout than between small parr and Brook Trout, and that intra-specific competition between salmon size classes was reduced by spatial segregation, shown in other studies, which was reflected by the differences in diet demonstrated in this study. In the May sample, all fish had been feeding predominantly on smelt eggs, a food item reported for the first time and reflecting the opportunistic feeding of these fluvial salmonids.

Key Words: Brook Trout, *Salvelinus fontinalis*, Atlantic Salmon, *Salmo salar,* feeding, stream, Newfoundland.

The fish fauna of Wings Brook, Newfoundland, is dominated by co-existing Brook Trout, *Salvelinus fontinalis* (Mitchill), and Atlantic Salmon, *Salmo salar*, L. (Hutchings 1986). Studies on the feeding habits of Brook Trout (e.g. Needham 1930; Logan 1963; Power 1980) and Atlantic Salmon (e.g. White 1936; Jones 1959; Keenleyside 1967) suggest that both salmon and Brook Trout are generalized feeders responding to available food resources. However, few studies have evaluated the diets of these species when they occur sympatrically (Elson 1940; Gibson 1973; Williams 1981; Gibson et al. 1984), and none have analyzed inter- and intra-specific competition between size classes.

The objectives of this study were to investigate the diets of Brook Trout and juvenile Atlantic Salmon in Wings Brook during seasonal periods of major feeding, and to evaluate possible competition for food with regard to inter-and intra-specific competition between size classes.

Study Site

Wings Brook is located on the northeastern coast of Newfoundland in Terra Nova National Park (53°55′07″W, 48°37′51″N) and flows into the southwestern arm of Alexander Bay. The main stem drains two lakes by two second order streams which converge 1.03 km from the mouth (for details see Hutchings 1986). The study area was 150 m upstream from the mouth, and 30-50 m long with a mean width of 5.8 m. The riparian vegetation consisted mostly of grasses and shrubs; Black Spruce (*Picea mariana*) and Speckled Alder (*Alnus rugosa*) overhung approximately 5 percent of the water surface. Undercut banks covered 5 percent of the water surface. The substrate was visually assessed as consisting of 60% cobble (> 6-15 cm), 20% rubble (> 15-26 cm), 10% pebble (> 3-6 cm), and 5% gravel (2-30 mm). At intermediate water levels the type of water flow within the site consisted of 95 percent riffle (shallow, broken surface) and 5 percent flat (shallow, smooth surface). The average depth ranged from 16.2 cm to 20.0 cm with a maximum depth of 43.0 cm on the five dates sampled. The water was clear but brown-tinged, slightly acidic (pH 6.2-6.8), and had a relatively low conductivity (30 μmhos). Water temperatures ranged from approximately 2°C in December to 23°C in August.

Materials and Methods

Fish were collected by electrofishing upstream (to avoid catching fish that might have fed on drift disturbed by electrofishing downstream). The fish were killed with carbon dioxide formed by dissolving Alka Seltzer tablets in water.

Fork length (to nearest mm) and whole weight (to 0.01 g) were measured for each fish. Sex was determined by visual inspection of the gonads, and a scale sample was removed for ageing. The fish was then preserved in 10 percent buffered formalin.

The maximum gape (mm) was measured, and the stomach removed by severing the esophagus and pylorus. Stomach fullness was estimated using the points system described by Hynes (1950), where an empty stomach is awarded 0 points, a full stomach 20 points, and a distended stomach 30 points, with corresponding points for intermediate values. Categories were allocated to various prey groups (Figure 1) and were considered equal for purposes of statistical analysis. The percentage contribution of each category to the overall diet was calculated by dividing the relative points value for each category by the total fullness value for each fish group, and multiplying by 100. Thus the percentage contribution of category

$$\text{“a”} = \frac{\Sigma\, Ca}{\Sigma\, Fi} \times 100,$$ where Ca

is the contribution of points of prey item "a", and F is the fullness index for each fish in the sample.

In order that fish with similar mouth size could be compared, "small" and "large" size classes of fish were created. By regressing maximum gape by fork length for each species, two fork length classes were created, in each of which salmon and trout had the same sized gape. The chosen cutoff points were a length of 6.0 cm for trout, representing 0+ fish, larger fish representing older groups, and 8.9 cm for salmon, below which approximated underyearling and yearling fish.

Diet breadth was calculated using Levins' (1968) index:

$$B = 1/Pi^2$$

where Pi is the proportion of item i in the diet of the population.

Resource overlap values were calculated using Pianka's (1973) equation:

$$ij = [PxiPxj/\ (Pxi^2Pxj^2)^{0.5}]$$

where Pxi is the proportion of prey type x used by species i, and Pxj is the proportion of prey type x used by species j. This index ranges from 0 (no overlap) to approximately 1 (identical diets) with a value exceeding 0.6 considered biologically significant (Zaret and Rand 1971). Analysis of variance with associated range tests (Scheffe-Tukey) and non-parametric (Mann-Whitney, Median) tests were used to compare monthly differences in fullness and number of food categories ingested.

Results

Two hundred and six salmon and 115 Brook Trout were caught from the study site over five sampling periods between 10 May and 6 December. The total number of fish per sample ranged from 94 in May to 22 in December and reflected sampling time, electrofishing efficiency, and seasonal changes in fish abundance. Salmon outnumbered trout by ratios of at least 1.33-1, with a maximum ratio in December of 6.33-1. Both species had an overall ratio of nearly two males per female, with an especially high percentage (91 percent) of male salmon parr in August.

The majority of fish of both species were underyearlings and yearlings. Excluding two 4-year-old smolt caught in May (18.5 cm and 19.7 cm), salmon ranged in age from 0+ to 3+ yr and were 3.1-13.2 cm in fork length. Trout ranged in age from 0+ to 6+ yr and had fork lengths of 3.1-31.5 cm. Other fish species present in the Wings system during sampling included the American Eel

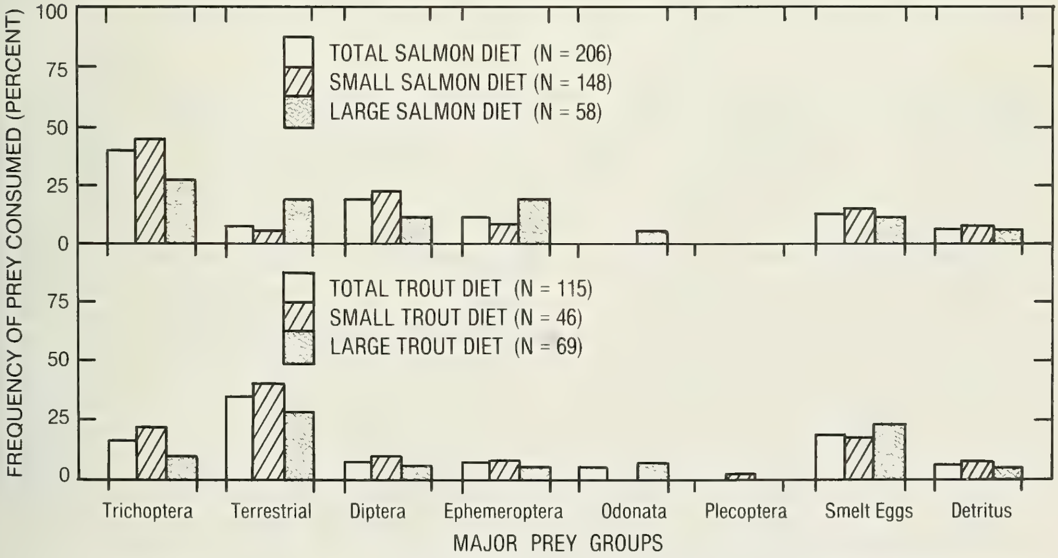

FIGURE 1. Summary of prey groups (> 2% contribution) consumed by Wings Brook Atlantic Salmon and Brook Trout.

(*Angulilla rostrata*), Rainbow Smelt (*Osmerus mordax*), Threespine Stickleback (*Gasterosteus aculeatus*), Ninespine Stickleback (*Pungitius pungitius*), and Fourspine Stickleback (*Apeltes quadracus*).

Aquatic invertebrates were more common in salmon stomachs than in trout stomachs, comprising an average of 59.2 percent of the total salmon diet, and 23.8 percent of the total trout diet (Figure 1). Aquatic invertebrate groups most commonly found in salmon stomachs were Trichoptera (38.3 percent), Diptera (19.0 percent), and Ephemeroptera (10.1 percent). Surface prey of terrestrial origin were more common in trout stomachs (30.4 percent overall) than in salmon stomachs (10.2 percent). Trichoptera (15.3 percent) were the only aquatic insect group comprising more than 10 percent of total trout stomach contents.

In small salmon, 72.5 percent of the total stomach volumes were composed of aquatic invertebrates, of which Trichoptera and Diptera were most important, and only 7.1 percent of their stomach contents were of terrestrial origin. Terrestrial foods were more common in large salmon stomachs (21.4 percent) than in small salmon stomachs. Aquatic invertebrates comprised 60.5 percent of stomach contents of large salmon. Terrestrial organisms were found more frequently in stomachs of small Brook Trout (36.3 percent) than in small salmon, and large Brook Trout consumed a higher proportion of terrestrial food (26.5 percent) than did large salmon.

In May smelt eggs were the dominant food comprising over 70 percent of the total stomach contents for all fish (Figure 2). Aquatic invertebrates (Diptera, Trichoptera) were more common in the stomachs of salmon than were terrestrial foods in June, whereas terrestrial and aquatic prey (Trichoptera, Odonata) were found in equal proportions in trout stomachs. Larval Odonata (Gomphidae) were more common in the stomachs of large salmon and trout than in small salmon stomachs in August, but Trichoptera (*Glossoma nigrion, Lepidistomata* sp., *Hydroptila metaoca, Rhyacophila fuscula*) remained an important food for all fish.

Trout and large salmon ate a high percentage of terrestrial food, but small salmon fed primarily upon Trichoptera (*Lepidistomata* sp., *Hydropsyche glossonae, Hydroptila metaoca*), and Diptera (Chironimidae). Trichoptera (*Lepidistomata* sp., *Hydropsyche sparna, Rhycophila fuscula, Glossoma nigrion*) were the most common prey items in salmon and trout stomachs in October. Again, food of terrestrial origin was more important to trout and large salmon than to small salmon. In December, terrestrial food was common in the stomachs of small trout, but was absent from the stomachs of large fish. The results for trout were suspect due to low sample size (n = 3).

Salmon demonstrated gradual decreases in stomach fullness from May to December, other than in the June samples when both species had little food in their stomachs (Figure 3).

There were no inter-specific differences in the number of food categories ($P > 0.05$) present in stomachs. Both salmon and trout had very low diet breadths in May (Figure 4) since they preyed predominantly on one item: smelt eggs. A wider diet breadth was demonstrated by large salmon in June, small salmon in August, and salmon compared to trout in December.

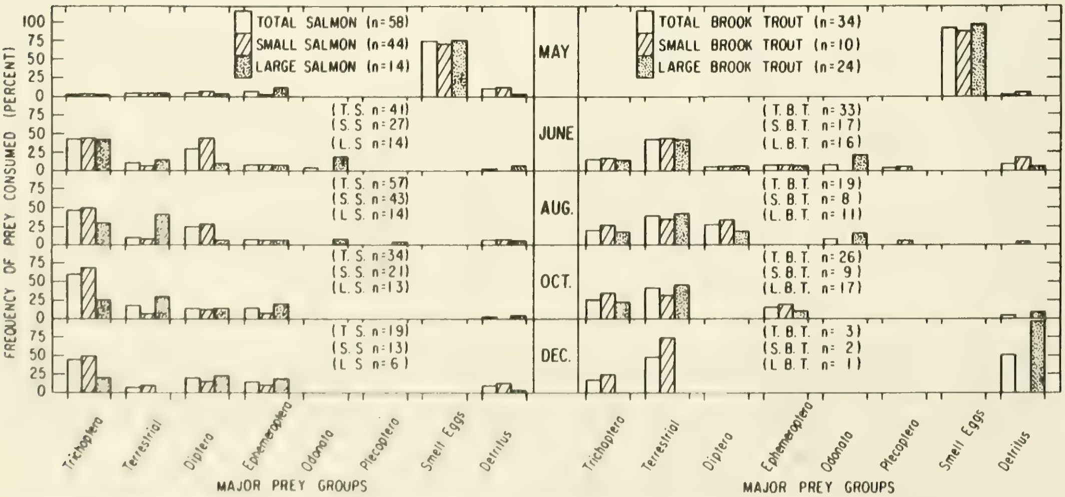

FIGURE 2. Monthly summary of prey groups consumed by Wings Brook Atlantic Salmon and Brook Trout.

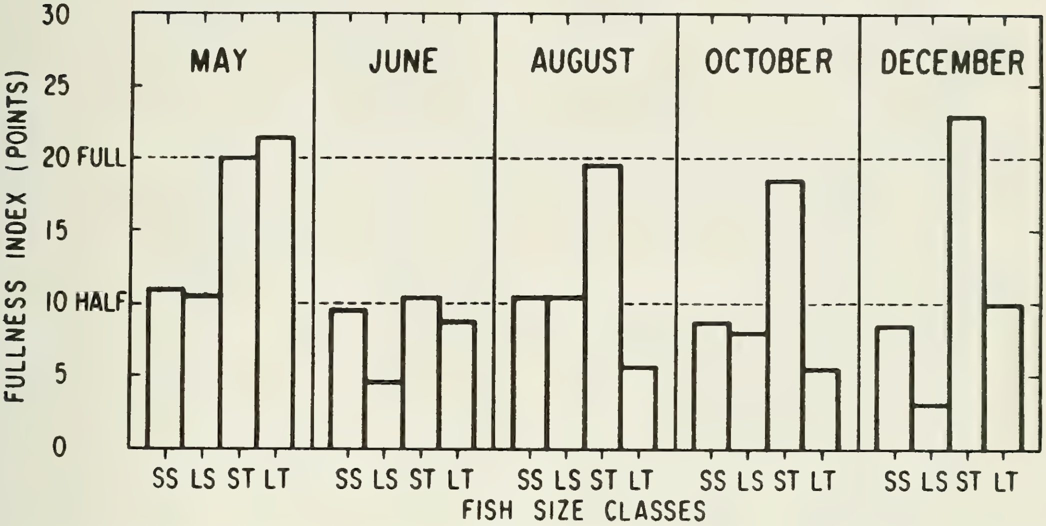

FIGURE 3. Stomach fullness indices of Wings Brook Atlantic Salmon and Brook Trout by size class (sample size as shown in Figure 1), SS = small salmon; LS = large salmon; ST = small trout; LT = large trout.

Large salmon and large Brook Trout had a higher inter-specific overlap value than did small salmon and small trout in all months but May (Figure 5). Trout size classes had higher monthly intra-specific overlap than did salmon size classes for all months sampled except for May, when it was the same (Figure 6).

A regression of mean food size with gape for Brook Trout (r = 0.33) and salmon (r = 0.10) resulted in no positive linear relationship ($F > 0.05$) (Figure 7). However, larger prey were taken by large parr compared to small parr ($P < 0.05$) in October (Figure 8). Large trout ate larger food in June than did small trout and salmon ($P < 0.05$).

Large salmon parr ate larger prey in December than in May and June. Small salmon ate larger prey in December than in other months ($P < 0.05$). Large trout ingested larger prey in June compared to other months, but there was no significant monthly difference in the size of prey consumed by small trout ($P > 0.05$).

Discussion

Salmonid diets are closely linked to the life histories of the available food organisms and have a wide spectrum comprising bottom organisms, drift and surface organisms (Wankowski and Thorpe 1979a).

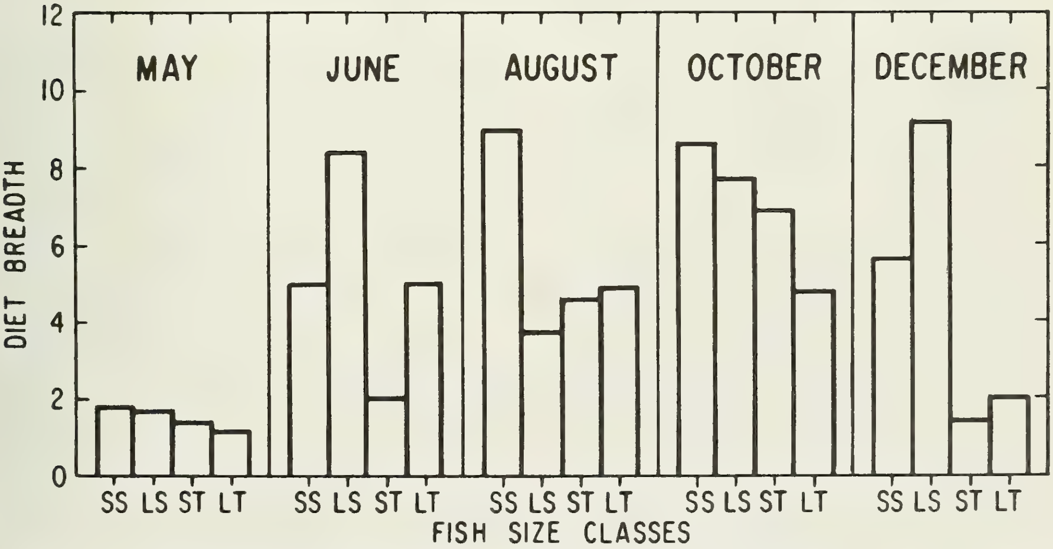

FIGURE 4. Monthly diet breadth values of Wings Brook Atlantic Salmon and Brook Trout.

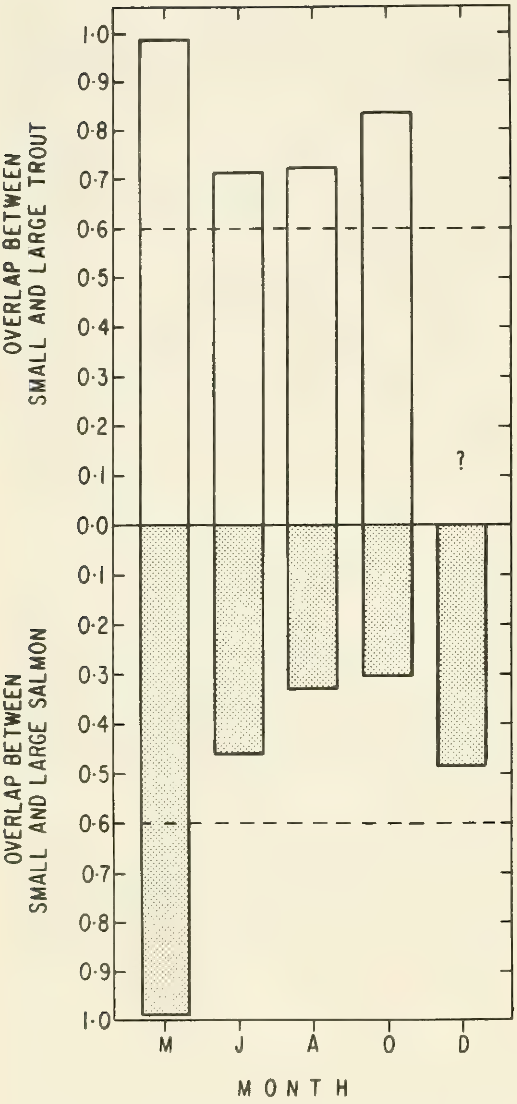

FIGURE 5. Inter-specific diet overlap between large (salmon > 8.9 cm, trout > 6.0 cm) and small Wings Brook Atlantic Salmon and Brook Trout.

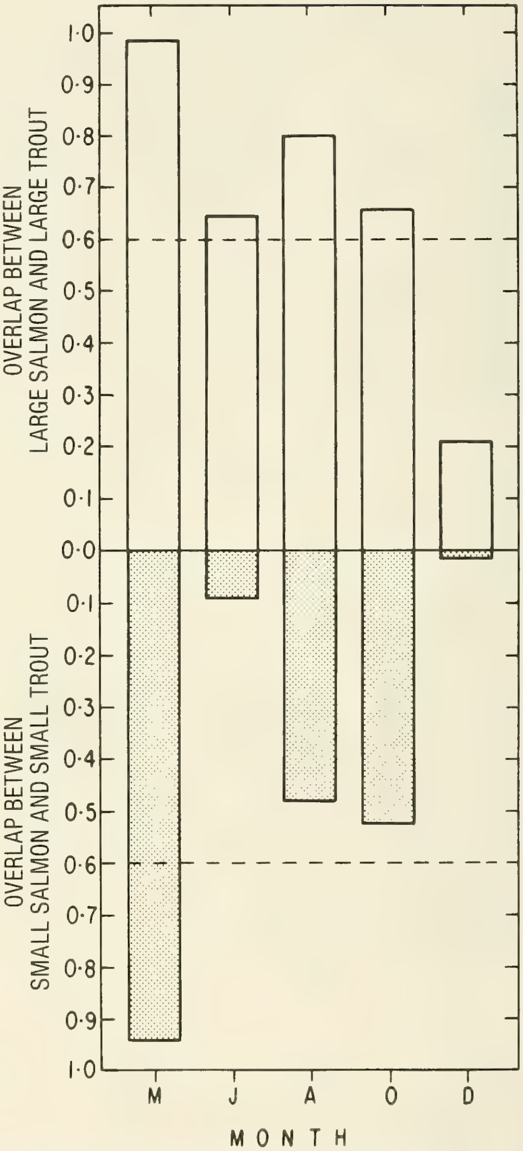

FIGURE 6. Intra-specific diet overlap between Wings Brook Atlantic Salmon and Brook Trout.

Feeding by salmonids on fish eggs has been previously reported by Ginetz and Larkin (1976), Frost (1976), and Frost and Brown (1967). However, these authors did not document salmonids ingesting eggs other than those originating directly from salmonid spawning, nor were these eggs a primary food source as they were in Wings Brook fish stomachs. We have, however, found eggs of Threespine Stickleback in stomachs of Brook Trout and Brown Trout, *Salmo trutta* (unpublished data).

May was the only month in which the same food (smelt eggs) was eaten irrespective of fish species or size, whereas inter-specific and/or intra-specific differences were observed in other months. This suggests that this food item was abundant during sampling in May, but that individual prey items were not abundant in other months.

Studies by O'Connor and Power (1980) reported that bottom organisms formed the greatest proportion of food eaten by trout in the spring, and as terrestrial drift increased later in the season, these items became more important in the trout diet.

The higher proportion of aquatic food found in Wings Brook salmon stomachs compared to trout corresponds to the findings of Gibson et al. (1984), but differs in the present study in that there was a

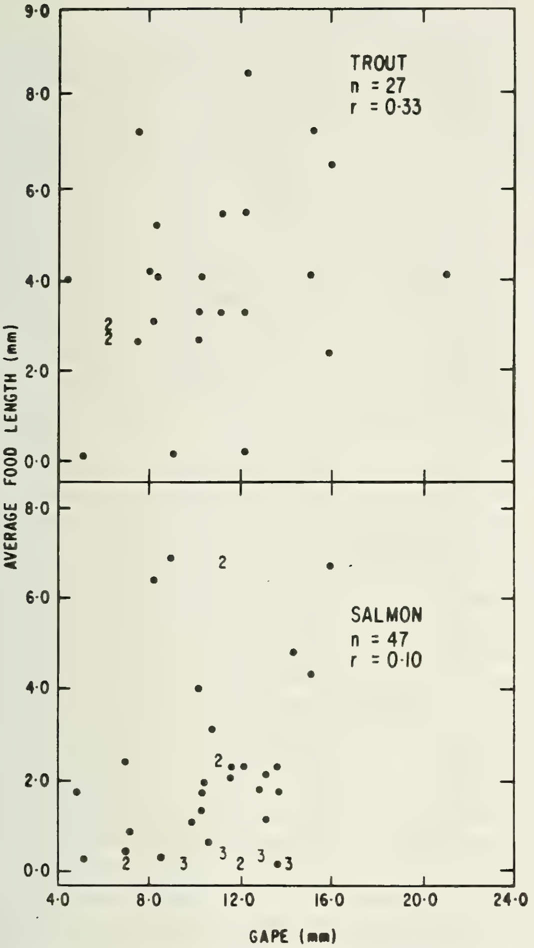

FIGURE 7. Regression of mean food length versus maximum gape for Wings Brook Atlantic Salmon and Brook Trout.

relatively small increase in the amount of surface food taken by Wings Brook fish from spring to fall.

Investigation of seasonal changes in fullness trends by Benson (1953), Power (1980), and Gibson et al. (1984) revealed greater fullness in the spring and early summer, with a gradual decrease as the summer progressed. Wings Brook salmon followed this trend more closely than did the trout. The decreased fullness in June by both species did not correspond to previously reported seasonal changes in fullness.

Since fluctuations in diet breadth are directly related to resource availability (Levins 1968; Feinsinger et al. 1981), results other than the May sample reveal that the selection of a given invertebrate prey reflects availability within a habitat.

The low inter-specific diet overlap in June for both small size classes could be due to the emergence of many aquatic insect species at this time; however, stomach fullness indices do not indicate an abundance of prey. Aquatic and terrestrial invertebrates, however, are usually most numerous in spring and early summer (e.g. Logan 1963; Frost and Brown 1967). A seasonal variance in overlap, therefore, could have been a result of fluctuating availability of terrestrial food items, resulting in gradually increasing resource partitioning by salmon and increased diet overlap of Brook Trout from June to October. Fluctuations in the availability of prey may influence the intensity of competitive interactions when food types are shared, but changes in the invertebrate taxa prevent one prey species from becoming a singly limiting food resource (Angermeier 1982).

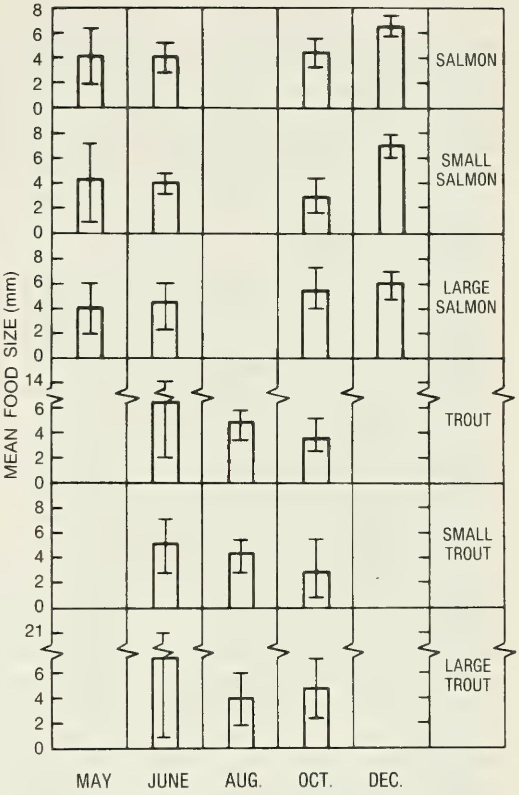

FIGURE 8. Monthly mean size of Wings Brook Atlantic Salmon and Brook Trout stomach contents. Bars indicate standard deviation on either side of the mean.

There was considerable diet overlap between large trout and small trout from May to October. Reduced similarity in diet might be expected between large and small fish due to wider range of food available to large fish which have a wider gape. However, the relationship between prey size and predator size reported by several researchers (e.g. Ricker 1932; Allen 1941; Lindstrom 1956; Nilsson 1957; Hartman 1958; Ringler 1979; Wankowski 1979; Wankowski and Thorpe 1979b) was not demonstrated in Wings Brook fish. The larger mean food size observed in June by large trout was due to the presence of unidentified fishes and a small mammal (shrew) in the food taken, whereas the December maximum for salmon was due to a larger species of Trichopteran available at that time of year (Thonney 1984). Allan (1978) found that Brook Trout showed a strong preference for larger prey.

The close relationship expected between behavioral selectivity and morphological limitations of the food-capturing mechanisms was not observed in Wings Brook fish; this suggests that prey may not have been available in abundance for the optimum size to be selected, and reflects the opportunistic type of feeding by both species. Although invertebrate species ingested by the different size classes of trout and salmon were at times dissimilar, there are indications that larger food items were lacking in the Wings Brook system (Thonney et al. 1987), and foraging was therefore limited to smaller, rather than "optimally", sized prey items. Similarly, Bannon and Ringler (1986) found in a second order stream that the most abundant prey of Brown Trout had sizes near the minimum which would be eaten, so that prey of predicted optimum size was rare. Gape size in Wings Brook salmon and Brook Trout did not appear to be as important an influence as was prey availability in determining the diet, even if food size preferences between the various size groups may be different. Diet composition in other salmonids has been shown to be strongly influenced by relative abundance of prey types (Ringler 1985; Bres 1986). Aquatic invertebrates in Wings Brook appeared to have similar levels of abundance as in a number of other Newfoundland rivers (Thonney et al. 1987) and salmonid food, rather than habitat, appears to be limiting for most times of the year in boreal rivers (Gibson et al. 1984).

The similarity of diet at a particular time does not necessarily indicate direct competition because availability of the food resource fluctuates regardless of its exploitation (Angermeier 1982). An example is the feeding by both species on smelt eggs. If this food were not in short supply, competition would be unlikely even though the same food was eaten by all size classes. However, based on overlap and fullness indices it is possible to suggest times when competition would most likely have occurred. Competition was probably lowest in the May sampling period, when an abundant food resource (smelt eggs) was available. Competition was probably more severe during June and August as indicated by reduced stomach volumes, and when rates of metabolism would be high in the warmer water.

Inter-specific competition was probably most severe between large salmon parr and trout. Intra-specific competition between large and small salmon may have been reduced by differences in diet, and possibly segregation of habitat. Intra-specific competition between small and large trout may have been severe from June to October although habitat differences are probable. From June to December the composition of stomach contents was quite variable, and reflected diel and seasonal changes in the prey base.

Territories set up by salmon parr in riffle areas tend to reduce intra-specific competition by dispersion and spatial isolation (Schoener 1971), a substitution for direct competition for food (Chapman 1966). However, social behavior of salmon parr and Brook Trout can be affected by a number of factors, including water velocity, availability of food, and temperature (Gibson 1988).

A number of papers have shown that juvenile Atlantic Salmon tend to be found in shallow rapids or riffles rather than pools, and that Brook Trout are generally in slower and deeper water than salmon (Keenleyside 1962; Gibson 1966; Gibson and Myers 1987). Small salmon parr are generally found in shallower, faster water than large parr, which are found in pools more often than are small parr (Symons and Heland 1978).

In an experimental stream tank both Brook Trout and young salmon were observed to feed throughout the water column, including at the surface (Gibson 1981). However, young salmon were closer to the substrate in faster flows than in slower flows, were frequently in contact with the substrate, but were higher off the substrate at 20° C than in cooler temperatures. Salmon parr off the substrate would more frequently rise to the surface than those close to the substrate. Also, dominant salmon parr, which were larger, were farther off the bottom than subordinates, and would more frequently feed at the surface than subordinates, and had larger territories. Movement and feeding in the water column and at the surface frequently initiated attack by a dominant fish, so that reduced feeding movements near the bottom or inactivity of submissive fish would decrease the number of attacks. In the same study, Brook Trout were seen to be more mobile than salmon, to hold stations above the substrate, and to frequently feed from the surface. The dominant fish in an experiment usually showed the best growth. The distribution of dominant fish was related to the source of food rather than to the attraction of a preferred water velocity. It has also been shown that Brook Trout and salmon parr (Gibson et al. 1984), as demonstrated with Brown Trout and salmon parr (Egglishaw 1967), in flats and pools take more surface prey than they do in riffles.

These observations would suggest, as was observed in the present study, that Brook Trout would eat more surface prey than salmon parr, and that large salmon parr would take more surface prey than small parr. One might expect competition to be most severe where there is greatest overlap of habitat, and since dominance is based largely on size, one would expect large trout to have a negative impact on the growth of large parr, which are frequently found in pools, and large salmon parr to have a negative impact on small trout, which frequently inhabit flats and deeper riffles, as has been confirmed in other studies (Gibson 1973; Gibson and Dickson 1984; Gibson and Myers 1987).

In Newfoundland salmon parr may also inhabit lakes, immigrating from nursery areas in streams primarily as yearlings (Pepper et al. 1985). A major part of the diet of both salmon parr and Brook Trout in a shallow lake with abundant macrophytes in central Newfoundland has been found to consist of Odonata nymphs (P. M. Ryan, DFO, St. John's, personal communication), a prey that was of little significance in the present study, due to its low availability in lotic conditions, and due to differences in feeding behavior related to water velocities (Gibson 1988). Therefore general predictions from particular studies cannot logically be made without also considering habitat and the availability of the invertebrate food.

It appears therefore that the feeding of Brook Trout and young salmon is opportunistic, as has been suggested for other fluvial salmonids (Thomas 1962; Tebo and Hassler 1963; Waters 1969) and that, although there may be competition for the amount of available food, in lotic conditions reduction in competition is not minimized by a restriction of the feeding niches. Rather, feeding is related to the availability of prey, and to behavior of the fish species related to water velocity and depth, and that competition for food between these species leads to shifts in habitat, by interactive segregation (Gibson 1973). The results of this study suggest that samplers which can quantify relative abundance of aquatic invertebrates with high availability factor (Allen 1941) in different habitats or systems, in conjunction with other habitat variables, could predict potential salmonid production (Gibson et al. 1984; Gibson et al. 1987; Thonney et al. 1987).

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Status of the Few-flowered Club-rush, *Scirpus verecundus* (Cyperaceae), in Canada*

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The Few-flowered Club-rush, *Scirpus verecundus*, is restricted in Canada to two areas within the western Lake Ontario drainage basin in southern Ontario. It was first discovered in the Hamilton area in 1955 and in the Toronto area in 1976. It occurs on dry mesic slopes in hardwood-pine forests on neutral to slightly acidic coarse soils developed over calcareous bedrock. This species is rare in Canada, but its populations appear to be stable.

Key Words: *Scirpus verecundus*, Few-flowered Club-rush, Ontario, rare, distribution, population size.

The Few-flowered Club-rush, *Scirpus verecundus* Fernald, is one of very few true woodland members of this genus in Canada. It is most closely related to *S. clintonii* A. Gray, a species which is also considered to be rare in Ontario (Ball and White 1982a,b). Since it is a small, vernal herb with a superficial vegetative resemblance to other co-occurring woodland sedges such as *Carex pensylvanica* Lam., *S. verecundus* may be difficult to detect when it is not in flower.

Scirpus verecundus is a tufted perennial with culms 1-4 dm tall that arise from short rhizomes. The flat, dark green, shiny, narrow (1-2 mm) leaves often exceed the culm. The single, terminal spike contains four to eight flowers and is about 5 mm long. The spike is subtended and equalled or slightly exceeded by an erect, ovate bract which is prolonged into a short blunt awn 1-6 mm long. The midribs of the scales subtending the flowers also have short, sharp awns. Each achene is subtended by three to six bristles about as long as the achene (Figure 1).

Distribution

The range of *S. verecundus* encompasses much of the eastern United States north of the Carolinas from Virginia and eastern Missouri north to Maine, Pennsylvania and Ohio. It appears to be rare along the margins of its range in Maine (Ogden et al. 1948), Ontario (Ball and White 1982b), the Niagara frontier region of New York (Zander and Pierce 1979; Zenkert 1934), northern Ohio (Braun 1967), Illinois (Sheviak 1981), West Virginia (Clarkson et al. 1981), and Delaware (Tatnall 1946). However, it is common elsewhere in the Appalachian ranges and on the Coastal Plain (Hitchcock and Standley 1919; Seymour 1969; Taylor 1915).

The first Canadian stations were found in the Royal Botanical Garden properties in the Hamilton area between 1955 and 1958 by A. Tamsalu. It was not discovered in the Toronto area until 1976 [relevant specimens in HAM, TRT; acronyms according to Holmgren et al. (1981)]. Both of these areas are contained within the Niagara Forest Section of the Deciduous Forest Region (Rowe 1972). Figures 2 and 3 present the distribution of the species in Ontario and North America, respectively.

Habitat

All of the populations of *S. verecundus* in Canada occur on relatively steep slopes under the cover of Red Oak, *Quercus rubra* L., in association with *Carex pensylvanica.* Eastern White Pine, *Pinus strobus* L., is often present in the overstory. *Scripus verecundus* prefers sites in which the canopy is not continuous, but in which small gaps occur (the forest floor is subject to considerable sun-fleck activity). Some type of disturbance (selective cutting, fire, trail edges) is usually evident near populations of this species. At the Canadian sites, it prefers neutral to slightly acidic, coarse-textured soils (Table 1) developed over highly calcareous parent materials. Cation (K, Mg, Ca) and phosphorus contents at these sites vary considerably (Table 1), suggesting that *S. verecundus* is tolerant of a wide range of soil macronutrient conditions.

General Biology

Scirpus verecundus flowers in the spring (early to mid-May in the Ontario populations) before the

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*Based on a COSEWIC status report by the author. Copies of the report are available at cost from the Canadian Nature Federation, Suite 203, 75 Albert Street, Ottawa K1P 6G1. Rare status was approved and assigned by COSEWIC on 8 April 1986.

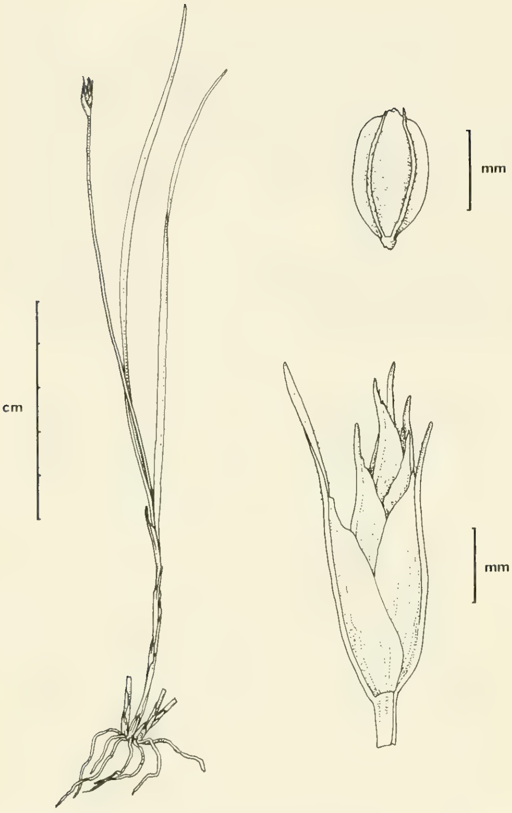

FIGURE 1. Habit, inflorescence and achene of *Scirpus verecundus.* Drawn from *Crins 6286, Sutherland & Varga; Crins 6312 & Dyer; Crins 6475* (relevant specimens in TRTE) by Lesley Bolm.

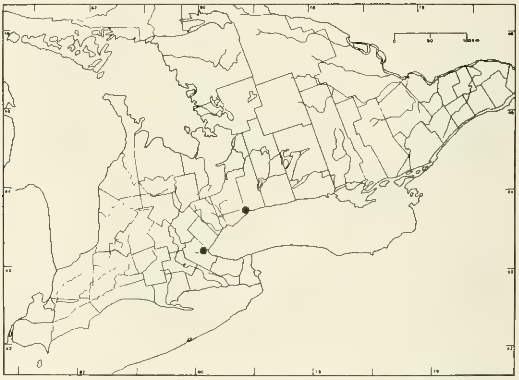

FIGURE 2. Distribution of *Scirpus verecundus* in Ontario.

forest canopy has developed. It shows the characteristic features of an anemophilous (wind-pollinated) plant, lacking showy perianth and nectaries and having relatively large, well exserted stamens and stigmas. Its flowers are protandrous (anthers emerging beyond scales before receptive stigmas), but the extent of outcrossing must be limited by the low stature of the plants and the irregular terrain in which the populations occur. Seed dispersal is well under way by late July and is virtually complete by early to mid-August. By late July, the leaves and culms become matted on the forest floor. This feature undoubtedly facilitates local dispersal and suggests a mechanism by which dense colonies of clumps could become established. If this mode of colony establishment is correct, then adjacent clumps must be closely related genetically. Seed set is extremely high, in spite of this presumed low genetic diversity within populations.

Population Size and Trends

Seven populations of *S. verecundus* are known in Canada. These occur in two areas separated by approximately 90 km (east Toronto and west Hamilton). Within these areas, the populations are relatively close to one another. In the Rouge River valley of Toronto, the two populations are less than 1 km apart. The five populations in Cootes' Paradise (Royal Botanical Garden property), Hamilton, are all within 2 km of each other.

Due to the colonial nature of this plant, it is difficult to estimate the number of plants contained within each population. The clonal nature of the species, as well as its dispersal biology, contributes to this difficulty. All but one of the populations seen by the author in 1984 were composed of several hundred to thousands of fruiting culms. One of the Hamilton populations contained only eight small clumps with 5 to 30 flowering culms each.

Colonies generally occupy discrete areas. One population in Hamilton occupied an area approximately 10 x 10 m, with clumps evenly and closely spaced within this area. Another popula-

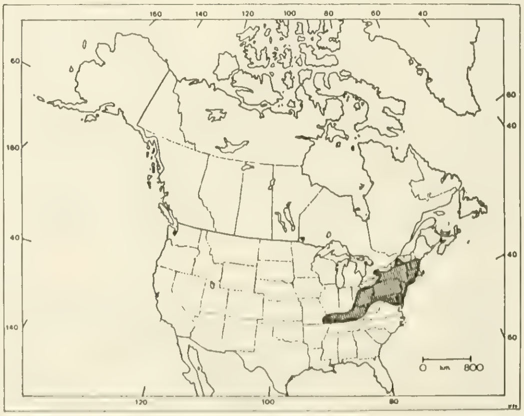

FIGURE 3. Distribution of *Scirpus verecundus* in North America.

TABLE 1. Soil sample data for five Canadian populations of *Scirpus verecundus*.

Site*	Date	pH	P	K	Mg	Ca	Texture
			(ppm in soil)				
1a	10 May 1984	6.9	53	104	88	1880	coarse
2a	21 May 1984	4.9	29	28	59	204	coarse
2b	21 May 1984	5.3	7	27	100	602	coarse
2c	21 July 1984	5.6	8	68	97	380	coarse
2d	11 August 1984	6.8	3	32	141	1286	coarse

*Site 1a is one of the Metropolitan Toronto Populations; sites 2a-d are Hamilton area populations.

tion occupied an area of approximately 10 x 1 m along a steep, narrow ridge. A third Hamilton population comprised a nearly continuous series of clumps covering about 8 x 5 m on both sides of a nature trail. Plants in all of these populations flowered and/or fruited profusely during 1984. Each clump contained several flowering culms, and the populations visited during July and August 1984 showed successful fruiting and seed dispersal (mature achenes and bare rachises).

No information is available regarding changes in population size. It is not possible to determine whether a given clump is of recent origin or whether it is declining. The Toronto populations were only recently discovered (the first in 1976), and they have not been closely monitored. The Hamilton populations, discovered between 1955 and 1958, appear to be healthy and contain large numbers of flowering culms. Thus, it is at least holding its own in this area.

Limiting Factors

On the basis of the sites which are occupied by *S. verecundus* in Canada, it would appear that light levels on the forest floor may be a limiting factor in the successful establishment of new clumps. Competition for space with *Carex pensylvanica*, a common, clonal associate, may also limit the establishment or spread of *S. verecundus*. Slightly acidic soils developed over calcareous bedrock are probably also required by this species.

Special Significance of the Species

Scirpus verecundus is one of very few simple-spiked, vernal, woodland species in the genus. Its highly reduced inflorescence makes it potentially useful in studies of the phylogeny of this large genus. Reduction generally represents evolutionary advancement, so that *S. verecundus* could yield valuable information in this regard.

Since *S. verecundus* can occur in fairly large populations on relatively steep banks under forest cover, it may play a minor role in local bank stabilization, along with other forest herbs.

Protection

Scirpus verecundus receives no formal legal protection in Canada. It has been listed as endangered in Illinois (Sheviak 1981) and rare in West Virginia (Clarkson et al. 1981). It has also been listed as nationally rare in Canada (L. Kershaw, J. K. Morton, and J. M. Venn. 1976. A list of rare or endangered species in the Canadian flora — vascular plants. Unpublished computerized list, Department of Biology, University of Waterloo, Waterloo, Ontario) and provincially rare in Ontario (Ball and White 1982b), but these listings do not afford any protection.

Evaluation of Status

Scirpus verecundus is considered to be rare in Canada. Although it is only known from two areas in southern Ontario, most of its seven populations are relatively large, apparently stable, and produce and disperse ample amounts of seed. There is no evidence of population reduction. There is no serious threat to its habitat at present, and it is quite possible that the species could be found in other suitable sites in the Niagara Peninsula or in the western Lake Ontario region.

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Polygyny, Extra-pair Copulations, and Nest Helpers in the Chipping Sparrow, *Spizella passerina*

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Intensive study of colour-marked Chipping Sparrows (*Spizella passerina*) on nine breeding territories at Guelph, Ontario, revealed a variable breeding strategy. Five pairs were monogamous, two males were apparently polygynous, and extra-pair copulations occurred on two territories. Helpers were also observed to assist with the raising of nestlings on one territory.

Key Words: Chipping Sparrow, *Spizella passerina*, polygyny, extra-pair copulation, nest helpers, Ontario.

More than 90% of all avian species are thought to be monogamous (Lack 1968; Oring 1982; Ford 1983). In some species previously suspected to be monogamous, the study of colour-marked populations has shown that extra-pair copulations (EPCs), polygyny and polyandry are occasionally employed to increase reproductive success (Ford 1983; Davies 1986; Middleton 1988a). In the absence of colour-marking, precise mating relationships are difficult to establish. As a result, the mating systems of many species probably are less well understood than they should be.

The monomorphic Chipping Sparrow (*Spizella passerina*) generally maintains monogamous relationships (Walkinshaw 1944, 1952). Walkinshaw (1959) suspected polygynous pair bonds when a nest, ultimately containing eight eggs (normal clutch three to four eggs), was tended by two females that were apparently paired to the same male. Keller (1979) confirmed one instance of polygyny in 32 observed pairings during two breeding seasons. She also observed several EPCs and suggested that male Chipping Sparrows actively pursued additional mating opportunities.

Between 1980 and 1985, a study of the impact of parasitism by the Brown-headed Cowbird (*Molothrus ater*) on the reproductive success of Chipping Sparrows was completed at Guelph, Ontario (43°32′N, 80°13′W) (Middleton 1988b). Of 493 Chipping Sparrow nests monitored during the study, six instances were known where more than one female apparently laid eggs in the same nest (two eggs deposited in a nest on the same day, or additional eggs appearing several days after completion of the clutch). In addition, one unbanded male in 1984 was observed to deliver food to two different nests on the same day. We suspected that the mating system among members of the study population was not uniformly monogamous, but without colour-banding we could only speculate on the mating strategies adopted.

Materials and Methods

In 1986 we trapped (mist-nets) and colour-banded (celluloid bands, A. C. Hughes, Middlesex, England) a discrete breeding population (nine pairs) of Chipping Sparrows. The birds occupied a 15-ha section of the University of Guelph campus, roughly delineated by the road network associated with the university's East Residence. The study area featured open grassy spaces surrounded by extensive and varied plantings including maples (*Acer* spp.), flowering trees (*Prunus* spp., *Malus* spp.) and conifers (*Juniperus* spp., *Pinus* spp., *Picea* spp., *Taxus* spp., and Eastern White Cedar, *Thuja occidentalis*).

Intensive observations on this population began with the return of the birds in late April and continued throughout the breeding season of 1986. Observations were made with binoculars (Zeiss 10x50) or telescope (Bushnell Spacemaster II, 20-40x zoom) from secluded locations close to the nests. Wherever possible, nests and their contents were checked daily during building and egg-laying. Thereafter, observations were maintained at nests to follow their progress and the involvements of individual birds.

Results

During the study, monogamy proved to be the most common breeding strategy and occurred in five of the territories under observation (Table 1). In these cases the behaviour of the pair during the nesting cycle was as generally described for the Chipping Sparrow (Stull 1968; Keller 1979). Elsewhere, polygny, extra-pair copulations, and helpers at the nest were observed.

Polygyny

Based on our understanding of Chipping Sparrow breeding behaviour, one case of polygyny was presumed and a second case was strongly suspected.

The presumed polygynous male was the first banded (Bl/Bk; see Table 1 for definition of colour codes) in 1985, which re-established a territory on the same site by 7 May 1986. Initially, the male was in the company of an unbanded female, and nest construction began around 10 May (nest 86-5A). The nest was abandoned (two Chipping Sparrow eggs) before 18 May, following nest parasitism by a Brown-headed Cowbird.

The previous day (17 May) the male had been seen in the company of another female that had been banded in 1985 (Wh/Wh). This second female was in the process of building a nest (86-4A) approximately 160 m from nest 86-5A. At this point it was unclear whether the male was paired to both females or had switched mates following abandonment of nest 86-5A. Nest 86-4A (two eggs) was parasitised and abandoned by 21 May.

A polygynous relationship was presumed on this day when the male was observed accompanying both females during construction of their second nests (nests 86-4B and 86-5B). Both females built their new nests within 25 m of their original nest sites, and the active nests were now separated by approximately 150 m. Four eggs were laid in nest 86-5B, and three young hatched on 5 June. The young successfully fledged on 13 June. Nest 86-4B was 9.5 m high in an 11-m Red Pine (*Pinus resinosa*) tree, and its contents could not be checked. The nest was abandoned for unknown reasons by 29 May.

During the following two weeks, the male spent most of his time in the company of the female from nest 86-5B. [She had been colour-banded on 29 May (Ye/Rd)]. Female Wh/Wh was observed on 11, 14 and 17 June delivering food to the young of nest 86-5B. On 18 June, a third nest of this female (nest 86-4C) was found approximately 150 m from 86-4B and within 50 m of 86-5B (now with fledged young). Three eggs were laid in 86-4C, and three young fledged on 12 July. The male simultaneously tended to the young from both nests, but spent an increasing amount of time at nest 86-4C as the fledglings from 86-5B approached independence.

The second suspected case of polygyny involved male Bk/Ye (banded 5 May 1986), which by 9 May was paired to an unbanded female. A nest was apparently under construction on 13 May and again on 21 May, although these nests were not subsequently located. The female was banded on 21 May (Ye/Wh), but the birds were not seen again until 1 June, when the male was found singing on an adjacent territory.

This territory, now numbered 86-7, had been previously occupied by male Bk/Wh and female Gr/Gr. Bk/Wh apparently abandoned the territory following predation of its nest on 31 May. On 1 June, Bk/Ye fed in the company of female Gr/Gr, and on the same day, copulated with another female (Gr/Rd) that had not been seen on the study site since being banded on 12 May 1986. This female was not subsequently observed on the territory, and we interpret the copulation as being an EPC, rather than constituting evidence of a cemented pair-bond. On 4 June, Bk/Ye was accompanying an unbanded female, and a nest (86-7) being constructed by this pair was found. The nest was completed by 6 June, but to the best of our knowledge no eggs were subsequently laid, and the female was seen again on the territory only once (17 June). On 5 June Bk/Ye was seen several times, accompanying and copulating with female Gr/Gr while she was carrying nest material. The nest was suspected to be high in > 10-m Norway Spruce (*Picea abies*) trees on residential land outside the study site, but it was never found. Gr/Gr was not seen again until 16 June when she was observed

TABLE 1. Summary of observations on the mating behaviour of nine colour-banded pairs of Chipping Sparrows, University of Guelph campus, 1986. See text for detailed descriptions. Colour codes are defined below.

Territory	Male	Female(s)	Polygyny?	EPC?	Nest Helper?
86-1	Bk/Wh	Gr/Gr	No	Yes (2)	No
86-2	Bk/Or	Gr/Bl	No	No	No
86-3	Bk/Rd	U.B.	No	No	No
86-4	Bl/Bk	Wh/Wh	Yes	No	No
86-5	Bl/Bk	Ye/Rd	Yes	No	Yes (2)
86-6	U.B.	Ye/Or	No	No	No
86-7	Bk/Ye	Ye/Wh Gr/Gr U.B.	Yes?	Yes (1)	No
86-8	U.B.	Or	No	No	No
86-9	Ye/Gr	Ye/Ye U.B.	No	No	No

Bk = Black; Bl = Blue; Gr = Green; Or = Orange; Rd = Red; Wh = White; Ye = Yellow; U.B. = Unbanded.

feeding in the company of male Bk/Ye. After this date, no reproductive activity by this pair was recorded, and no birds were seen on the territory after 1 July.

Because male Bk/Ye accompanied at least two different nest-building females during a five-day span, we suspect that this male maintained, at least for a short period, a polygynous pair bond. Males generally accompany their mates during nest construction (Walkinshaw 1944; Stull 1968; personal observation), and, because no other males were encountered on the territory held by Bk/Ye during this period, it was unlikely that these females were mated to other males. Unfortunately, only a single nest was found on the territory, and the presence of polygyny could not be confirmed. If polygyny did not occur, the observations at least substantiate EPCs by male Bk/Ye with at least two different females.

Extra-pair Copulations

Three EPCs were observed between colour-marked birds during 1986 (Table 1). This total excludes copulations between male Bk/Ye and the two females to which he was likely pair-bonded (Gr/Gr and unbanded), but includes the observed mating between this same male and female (Gr/Rd, see above). The two remaining EPCs involved male Bk/Wh (originally paired to Gr/Gr) and an unbanded female (Table 1) on 17 and 21 May. In addition, at least five other copulations were observed during 1986 that we believe represented EPCs.

These incidents involved marked males copulating with unbanded females at some distance from the males' known territories. Most of these encounters were recorded early in the season, when many birds on the study site were as yet unbanded. Following EPCs, males and females generally departed in different directions, unlike copulations between paired birds where both participants tended to depart together. Furthermore, on two occasions the male involved was chased away by another male, who then flew off with the female. Otherwise, there were no obvious differences in the behaviour of birds during EPCs and copulations between members of a pair.

In both types of matings, participants approached with a rapid "twittering" call. The male then slowly approached the female, which assumed a crouching position with wings quivering and tail extended upwards (*see also* Walkinshaw 1944). The behaviour of females during both types of copulation suggested that in this species, EPCs, like intrapair copulations, may be solicited or are at least unresisted by the female, rather than being forced upon her by the male (McKinney et al. 1984). Keller (1979) noted that in two of the three EPCs she observed, the female also apparently solicited copulation.

Nest Helpers

In addition to the observation of female Wh/Wh feeding young from the other nest (86-5B) of its polygynous mate, a second, unidentified bird was observed delivering food to nestlings at this same nest. This bird was first observed on 13 June, when the young from 86-5B had just fledged. When the nest was approached for inspection, three adult birds gave distraction displays around the nest. Two of these were the colour-banded parents of the young (male Bl/Bk and female Ye/Rd) and a third, unbanded individual. Approximately 10 minutes later, the unbanded bird delivered food to the tree where the fledglings were known to be, and was later observed to provide food to a begging fledgling. This sequence was repeated the following day.

Discussion

The evidence indicates that the Chipping Sparrows at Guelph are not uniformly monogamous. In 1986, at least one and likely two males employed polygyny as a breeding strategy. Furthermore, the solicited EPCs suggest that both males and females seek mating opportunities with individuals other than their mates. Although other authors (Walkinshaw 1959; Keller 1979) have made similar observations, the comparatively high incidence of breeding strategies other than monogamy encountered at Guelph suggest that the breeding behaviour of the Chipping Sparrow is more complex than previously supposed and may be similar to that of the Dunnock (*Prunella modularis*) (Davies 1986).

We suspect that EPCs in this breeding population may be substantially more frequent than we observed for at least two reasons. First, because almost all observations in 1986 were made by a single observer (DP) and only 0.5-2 h was spent observing the activities of each pair on a given day. It is likely that many copulations were unrecorded. Second, most copulations occurred in dense foliage, and in only 20-25% of the encounters could both participants be identified.

The Environmental Potential for Polygamy (EPP, Emlen and Oring 1977) is highest in species where one sex plays little or no role in nest-related activities. In the Chipping Sparrow, the female alone builds the nest and incubates the eggs (Stull 1968; personal observation), although in rare instances males have been known to incubate for short periods of time (Walkinshaw 1944). Both sexes feed the young with approximately equal frequency (Walkinshaw 1944; personal observation). Thus, males are free to pursue copulations with additional females during much of the breeding season.

Ford (1983) cited several species where territorial intrusions by males (probable attempts at EPCs) are more frequent early in the season (primarily during nest building and laying), when females are most receptive to fertilization. In the Chipping Sparrow, males in particular frequently wander off their territories early in the breeding season (personal observation). This behaviour appears to be most prevalent while their mates are incubating (*see also* Keller 1979). Because males generally accompany the female throughout the nest-building stage (Walkinshaw 1944; Stull 1968; personal observation), it is likely that they are less able to seek copulations with other females during this period. Similarly, territorial intrusions may be less frequent during brood-rearing, when males must spend a large proportion of their time on the territory to feed the young.

The complex habitats preferred by the Chipping Sparrow also may facilitate EPC. Most territories in our study area contained stands of dense conifers. In these habitats males could frequently enter an adjacent territory without being detected by the resident male. Additionally, the type of habitat and distribution of feeding areas could influence the mating relationship between pairs as identified for the Dunnock (Davies 1986), with which the Chipping Sparrow shares an ecological equivalence.

Our findings not only corroborate the fact that male Chipping Sparrows occasionally employ multiple matings to enhance reproductive success (Keller 1979), but also suggest that the breeding biology of this species may be highly variable and more complex than previously thought. We suspect that additional studies of colour-banded birds will reveal that departures from strict monogamy are commonplace in several avian species. In the meantime the Chipping Sparrow can be added to the list of species (*see* Oring 1982, 1986; Ford 1983; McKinney et al. 1984, for recent reviews) that resort to a variable breeding strategy. The complete understanding of that system needs further study.

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Nesting Ecology of Forest-dwelling Great Horned Owls, *Bubo virginianus*, in the Eastern Deciduous Forest Biome

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We investigated Great Horned Owl (*Bubo virginianus*) nest-site selection, productivity, prey items, and predation on sympatric raptors in extensive forest habitats of the Eastern Deciduous Forest Biome in New Jersey, New York and Connecticut. All nest sites were located in trees, mostly oaks (*Quercus* spp.), and were either old or recently usurped hawk, crow or squirrel nests. Eggs were laid in February or early March and young usually fledged by mid-May. Prey included at least 33 species of birds, mammals and fish but nongame birds were higher and lagomorphs lower compared to Great Horned Owl diets in open-country habitats. These dietary compensations may explain the lower productivity of young than typically reported in western North America. Adults or young of nine species of raptors nesting nearby were taken by Great Horned Owls.

Key Words: Great Horned Owl, *Bubo virginianus*, nest sites, forests, productivity, prey, sympatric raptor species, New Jersey, New York, Connecticut.

Most investigations of nesting Great Horned Owls (*Bubo virginianus*) in North America have been conducted in open-country habitats such as the mosaic of fields, farmland and woodlots of the eastern and central states (Baumgartner 1939; Boswell 1974; Craighead and Craighead 1956; Hagar 1957; Misztal 1974; Orians and Kuhlman 1956; Petersen 1979; Siminski 1976), grasslands and prairie of the Midwest (Gilmer et al. 1983; Luttich et al. 1971; Rusch et al. 1972), desert scrub of the Intermountain area and Southwest (Smith and Murphy 1973, 1982); forest edge of the West (Siedensticker and Reynolds 1971; Frounfelker 1977) and chaparral of the Far West (Fitch 1940, 1947).

Here we present information on nest sites, productivity, prey items and predation on sympatric raptors in extensive forest habitats of the Eastern Deciduous Forest Biome of the northeastern United States.

Methods

Nesting Great Horned Owls, uncommon in our study region, were found during the course of long-term breeding-bird and raptor studies (Bosakowski et al. 1987; Speiser 1981; Speiser and Bosakowski 1987) where most hawk nests were rechecked each year in addition to searches for new raptor nests and snags (for owls) in 1977-88. In this paper, we report only on those owls found nesting in heavily forested areas in and adjacent to the Reading Prong in New Jersey, New York, and northwestern Connecticut.

The Reading Prong is an extension of the New England Uplands, a belt of rolling, granitic hills stretching from northwest Connecticut, crossing southeast New York and northern New Jersey, and terminating in eastern Pennsylvania. Despite its proximity to New York City, much of the region is sparsely populated and composed of many state, county and private forests. Forests are predominantly oak (*Quercus* spp.), maple (*Acer* spp.) and hickory (*Carya* spp.) with small, scattered stands of conifers in some areas. A detailed description of the study area and major tree associations can be found in Speiser and Bosakowski (1987).

TB and RS searched south and west of the Hudson River (parts of Orange and Rockland counties in New York and parts of Bergen, Hunterdon, Middlesex, Morris, Passaic, Sussex and Warren counties in New Jersey) in 1977-88. DGS and his associates recorded data on nests found in the extensively wooded and rugged hills of northwestern Connecticut (Litchfield County) and along the forested traprock ridges extending southward (New Haven County) as part of a general study of the raptors of Connecticut from 1972-88. Nest searches were confined to areas known to be occupied territories as determined by visual sightings of adults, history of territorial occupancy or response of Great Horned Owls to play back of tape-recorded song.

Results and Discussion

Of 33 nests located, sixteen were formerly used by Red-tailed Hawks (*Buteo jamaicensis*), seven were nests of the Common Crow (*Corvus brachyrhynchos*), one was in a Red-shouldered Hawk (*Buteo lineatus*) nest, one in a Northern Goshawk (*Accipiter gentilis*) nest, two in Gray

Squirrel (*Sciurus carolinensis*) nests, one in a Red Squirrel (*Tamiasciurus hudsonicus*) nest, and five were of undetermined origin.

Nests were usually situated in crotches of moderate or large-sized live trees: eleven in Red Oaks (*Quercus rubra*), four in White Oak (*Quercus alba*), four in White Pine (*Pinus strobus*), two each in Eastern Hemlock (*Tsuga canadensis*), Red Maple (*Acer rubrum*), and Black Birch (*Betula lenta*), and one each in Tulip Tree (*Liriodendron tulipifera*), American Elm (*Ulmus americana*), White Ash (*Fraxinus americana*), Black Oak (*Quercus velutina*), Sycamore (*Platanus occidentalis*) and Shagbark Hickory (*Carya ovata*). Two nest tree species were undetermined. One Great Horned Owl pair chose an old Red-tailed Hawk nest located in remaining branches of a large dead snag.

Regarding overall habitat in New Jersey and New York, six nests were associated with forested wetland, four were on dry, wooded hillsides, three were in level, forested terrain and one was on the bank of a major river in a floodplain forest. All fourteen nests were located in mature and submature second growth forest. Six of the nests were also near edge habitat composed of early seral stages of the deciduous forest biome (Shelford 1963). In Connecticut, thirteen nests were located on dry, heavily forested hillsides, four were in forests along traprock ridges and two were associated with forested wetland.

By backdating from the approximate ages of the nestlings, we estimated that in New Jersey and New York incubation usually began during the last week of February or the first week of March. Egg dates for 12 Connecticut nests ranged from 11 February to 20 April, although the latter date probably represented a renesting attempt. Dates that young were in nests ranged from 12 March to 11 May. Generally, eggs were laid from mid- to late February, and young fledged during the last week of April or the first two weeks of May.

While incubating, the female often postured low in the nest bowl, perhaps to decrease visibility or to improve thermal protection of the eggs. Hawes (cited *in* Bent 1938) reported a renesting attempt after two eggs were frozen, but Austing and Holt (1966) and Houston et al. (1987) have observed Great Horned Owl eggs to be relatively resistant to cold stress. Typically, the owls' eyes were closed, or nearly so, when on the nest. This may be a part of their nornal concealment posture, or simply a feature of their diurnal sleeping behavior.

Productivity, figured from the late nestling stage, averaged 1.14 young reared per nesting attempt in New Jersey and New York. Six nests reared one young, five reared two young, two nests failed and one nest with eggs, located on the remains of an old Gray Squirrel nest, was blown out of the tree. Productivity of 10 Connecticut nests with complete nest records averaged 1.33 young per nest (range 1-3 young). Both productivity rates are lower than typically reported for the open biotopes of western North America (Colorado: Boswell 1974; Olendorff 1975; Utah: Smith and Murphy 1979; North Dakota: Gilmer et al. 1983).

We observed significant variations in annual productivity; 1985 and 1988 were peak years whereas 1979 and 1987 appeared to be years when breeding activities of Great Horned Owls decreased significantly or "crashed", as was observed for Great Horned Owls in Colorado (Olendorff 1975) and central Utah (Smith and Murphy 1979). Our data are not extensive enough to infer any periodicity or mechanism for these "crashes".

Nest-site fidelity in successive years was not observed, as also reported by Craighead and Craighead (1956) and Orians and Kuhlman (1956). The habit of using a nest only once probably reflected poor durability of most stick nests to trampling by adult and nestling Great Horned Owls. As Great Horned Owls are not known to repair their nests (Bent 1938; Orians and Kuhlman 1956), a safer strategy would be to move to a newer nest or one in better repair the following nesting season, or alternately they may usurp another raptor's newly constructed nest (Bent 1938; many others). Nests containing eggs and young were sometimes blown out of trees (Worth 1978; G. Hanisek, personal communication; this study), thus illustrating the selective pressure for choosing a durable nest.

However, there might be other factors explaining the lack of nest fidelity. Austing and Holt (1966) believed that Great Horned Owls moved to different breeding areas in successive years within a large home range, perhaps to exploit areas of higher prey abundance. Craighead and Craighead (1956) noted that most Great Horned Owls were limited to certain woodlots, but some movement was observed from year to year. Our observations were of both types, some pairs appearing to be nomadic whereas others were sedentary, occupying the same general territory for several consecutive years. Smith and Murphy (1973) also noted home-range fidelity extending over several consecutive years by some Great Horned Owl pairs.

Diets of Great Horned Owls during the nesting season were determined from prey found in the nest or from prey and pellets collected below nests or nearby roost trees from late winter to late spring (Table 1). Prey included 14 mammal species, at least 17 bird species and 2 species of fish. Several prey items, the Common Goldeneye (*Bucephala clangula*), the Green-backed Heron (*Butorides striatus*), Red-winged Blackbirds (*Agelaius

TABLE 1. Prey of Great Horned Owls found near nests or under nearby roost trees.

Prey Species	New Jersey-New York	Connecticut	Totals	% of totals
Mammals	32	130	162	57.6
Opossum, *Didelphis virginiana*	—	3	3	1.1
Hairy-tailed Mole, *Parascalops breweri*	1	—	1	0.4
Short-tailed Shrew, *Blarina brevicauda*	—	7	7	2.5
Unidentified shrews, *Sorex* spp.	—	2	2	0.7
Eastern Cottontail, *Sylvilagus floridanus*	2	4	6	2.1
Raccoon, *Procyon lotor*	—	3	3	1.1
Gray Squirrel, *Sciurus carolinensis*	15	11	26	9.3
Red Squirrel, *Tamiasciurus hudsonicus*	—	3	3	1.1
Southern Flying Squirrel, *Glaucomys volans*	—	1	1	0.4
Meadow Vole, *Microtus pennsylvanicus*	6	24	30	10.7
White-footed Mouse, *Peromyscus leucopus*	3	37	40	14.2
Muskrat, *Ondatra zibethicus*	1	6	7	2.5
Norway Rat, *Rattus norvegicus*	3	29	32	11.4
House Mouse, *Mus musculus*	1	—	1	0.4
Birds	42	68	110	39.1
Common Goldeneye, *Bucephala clangula*	—	1	1	0.4
Red-shouldered Hawk, *Buteo lineatus*	1	—	1	0.4
Eastern Screech Owl, *Otus asio*	1	2	3	1.1
Saw-whet Owl, *Aegolius acadicus*	—	1	1	0.4
Green-backed Heron, *Butorides striatus*	—	1	1	0.4
Ring-necked Pheasant, *Phasianus colchicus*	—	2	2	0.7
Common Grackle, *Quiscalus quiscula*	10	—	10	3.6
Common Flicker, *Colaptes auratus*	6	3	9	3.2
Mourning Dove, *Zenaida macroura*	1	—	1	0.4
Rock Dove, *Columba livia*	2	—	2	0.7
Unidentified flycatchers, *Tyrannidae* spp.	1	—	1	0.4
Common Crow, *Corvus brachyrhynchos*	4	8	12	4.3
Ruffed Grouse, *Bonasa umbellus*	2	5	7	2.5
American Robin, *Turdus migratorius*	3	2	5	1.8
Red-winged Blackbird, *Agelaius phoeniceus*	1	9	10	3.6
Blue Jay, *Cyanocitta cristata*	3	5	8	2.8
Unidentified passerines	7	29	36	12.8
Fish	0	9	9	3.2
White Sucker, *Catostomus commersoni*	—	6	6	2.1
Brown Bullhead, *Ictalurus nebulosus*	—	3	3	1.1
Totals	74	207	281	100.6

phoeniceus), Muskrats (*Ondatra zibethicus*) and fish, were found at nests associated with swamps or lake habitats. Generally, the diet of these forest-dwelling Great Horned Owls was high in nongame birds and tree squirrels and deficient in lagomorphs and game birds compared with studies in mostly open country (Craighead and Craighead 1956; Fitch 1947; Gilmer et al. 1983; Orians and Kuhlman 1956; Rusch et al. 1972).

We suggest that this compensatory shift in diet was the result of the generally poor habitat for cottontails (mature forest) and low populations of grouse in our study region. These dietary compensations may also explain the poor productivity we found for forest-dwelling Great Horned Owls compared to those nesting in open habitats of western North America. Boswell (1974) found that nesting Great Horned Owls in Ohio preyed more heavily on birds and had a lower productivity than nesting pairs in Colorado.

We found evidence of Great Horned Owl predation at a number of raptor nests which were being monitored concurrently in the study region (Table 2). The carcasses of adult raptors were only partially eaten and were apparently seldom transported back to the owl's nest. Nearly all were decapitated. Nestlings of several raptor species were also found dismembered or had disappeared (not the result of fratricide). These observations suggested that predation on other raptors by Great Horned Owls might have been largely overlooked had we not been monitoring nearby raptor nests.

TABLE 2. Evidence of Great Horned Owl predation on sympatric raptors found by concurrently monitoring neighboring raptor nests.

Raptor Species	Observations
Red-shouldered Hawk, *Buteo lineatus*	5 adults, 3 nestlings; 15 feathers of 1 adult found beneath Great Horned Owl nest*, 1 adult and 1 nestling found atop snag and on log near their nest, plus 2 nestlings missing, 3 plucked adult carcasses; 1 on its nest, 2 on elevated perches near their nest site.
Red-tailed Hawk, *Buteo jamaicensis*	3 adults; 1 carried by owl, 2 found decapitated.
Cooper's Hawk, *Accipiter cooperi*	2 nestlings plucked, eaten at nest, (entire brood); 122 m from Red-shouldered Hawk nest listed above.
Northern Goshawk, *Accipiter gentilis*	1 adult decapitated near its nest, with sheared feathers, notched keel.
Broad-winged Hawk, *Buteo platypterus*	1 adult decapitated on snag with sheared feathers.
Great Horned Owl, *Bubo virginianus*	1 fledgling decapitated with sheared feathers, near 2 pairs of owls.
Eastern Screech Owl, *Otus asio*	3 adults*; feathers and skull of 1 in pellets beneath Great Horned Owl roost site near nest, decapitated body of another in Great Horned Owl nest, kill under plucking tree 50 m from Great Horned Owl nest.
Barred Owl, *Strix varia*	1 adult; skull and feathers in Great Horned Owl nest (M. Redmond, personal communication).**
Long-eared Owl, *Asio otus*	1 adult; feathers in Great Horned Owl nest (M. Redmond, personal communication).**
Saw-whet Owl, *Aegolius acadicus*	1 adult*; feathers, synasacrum, wing beneath Great Horned Owl nest.

*Also reported in Table 1, as these prey remains were found by traditional food habits study techniques.
**Not reported in Table 1 since these items were selectively collected without other prey items being recorded. Specimens were verified by DGS.

Thus, some traditional food studies may have underrepresented other raptors as prey items.

Other raptor studies have also documented or attributed loss of nesting adults and/or young to Great Horned Owl predation (Bent 1938; Craighead and Craighead 1956; Orians and Kuhlman 1956; Hagar 1957; Houston 1975; Luttich et al. 1971), but few food habits studies have reported large numbers of raptor remains at Great Horned Owl nests. Alternately, predation on raptors may have been higher than expected in our study region because of the low availability of large prey (rabbit and grouse).

Our findings indicate that forest-dwelling Great Horned Owls have a low productivity and may not nest every year. Although Great Horned Owls have a wider food niche (Knight and Jackman 1984) and greater habitat flexibility than other sympatric owls (Bosakowski et al. 1987), we conclude that this species is more successful in open habitat, especially outside the Eastern Deciduous Forest Biome.

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Pat and Mike Redmond and Pete Devers located the Great Horned Owl nests in Connecticut in 1974 and 1975 and generally introduced DGS to Great Horned Owl habitats and territories in northwestern Connecticut. Nancy and Walter Lilly and Paddy French provided information about Great Horned Owl nests and John Benzinger assisted with nest searches in New Jersey. E. O. Garton shared information about Idaho owls.

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Distribution and Abundance of Small Mammals in Lake Superior Provincial Park, Ontario

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A survey of small mammals in Lake Superior Provincial Park (LSPP), Ontario, was conducted during the summers of 1983 to 1985. Nineteen traplines were set in six major vegetation zones: the southern deciduous and coniferous forests, boreal forests, coastline habitats, wetlands, and river lowland. A total of 890 small mammals was trapped. The four most abundant and widely distributed species were *Peromyscus maniculatus* (Deer Mouse), *Sorex cinereus* (Common Shrew), *Clethrionomys gapperi* (Northern Red-Backed Vole), and *Sorex fumeus* (Smoky Shrew). The abundance and distribution of omnivores, insectivores and herbivores is different between some plant communities within the park.

Key Words: Lake Superior Provincial Park, small mammals, abundance, distribution, insectivores, herbivores, omnivores, Ontario.

Some limited and casual collecting had been done previously in Lake Superior Provincial Park (LSPP), but little information has been available on its small mammals. During the course of three summers (July-August 1983, July-August 1984, and August 1985) we conducted a survey to determine the distribution and abundance of small mammals in different habitats of the park. We compare our results with an earlier survey of Quetico Provincial Park and comment on the different abundances of species related to differing plant communities within Lake Superior Provincial Park.

Study Area

Lake Superior Provincial Park is situated in the Algoma section of the Great Lakes–St. Lawrence Forest Region (Rowe 1972), about ten kilometers south of Wawa, Ontario. The park is predominantly a mixture of two types of forests: the Great Lakes–St. Lawrence Forest Region is found on the east and west sides of Lake Superior, while the Boreal Forest Region lies north of the lake (Rowe 1972). LSPP covers an area of approximately 1556 square kilometers and lies within the southern section of the Canadian Shield (Figure 1).

The topography of the park clearly indicates evidence of former volcanic activity, mountain formations, faults, and glacial erosion, resulting in rugged coastlines, cobble beaches, sand dunes, hills, bluffs, lowlands and numerous lakes and rivers. The moderating effect of Lake Superior is an important factor responsible for the northern extension of the Great Lakes — St. Lawrence harwood forest (T. J. Beechey, 1972. Ecological inventory of Lake Superior Provincial Park. Ontario Ministry of Natural Resources. 1979. Lake Superior Provincial Park Master Plan. 70 pp.).

Materials and Methods

Nineteen traplines were set in six major vegetation zones of the park: the southern deciduous (SDF) and coniferous forests (SCF), boreal forests (BF), coastline communities (C), wetlands (W), and river lowland (RL). Table 1 outlines these vegetation zones, the traplines corresponding to each zone, location of all traplines, and an overall description of the habitats. Detailed descriptions of different plant communities, analysis of vegetation, and extensive plant species lists of LSPP may be found in Beechey (1972. Ecological Inventory of Lake Superior Provincial Park. OMNR).

All traplines contained 40 trapping stations spaced 10 m apart. At even-numbered stations one snap trap (Museum Special) and one conical pitfall trap (Nelles and Taber 1974) were set; at odd-numbered stations two snap traps were used. Snap traps were baited with peanut butter and rolled oats, and pitfalls were unbaited. Each transect line was trapped for five consecutive nights (1983-1985) for a total of 7600 trap nights, and all traps were checked daily. Relative abundance of small mammal species was calculated as the number of animals caught per 100 trap nights. Roadkills, the occasional use of mist and hoop nets, and a .410 shotgun provided additional specimens.

Mammals were identified from descriptions given by Whitaker (1980) and Peterson (1966) and were prepared as voucher specimens for the Royal Ontario Museum [ROM] (complete specimen catalogues (1983 — 88433-88799, 1984 — 90185-90373, 1985 — 91576-91953) are on file in the

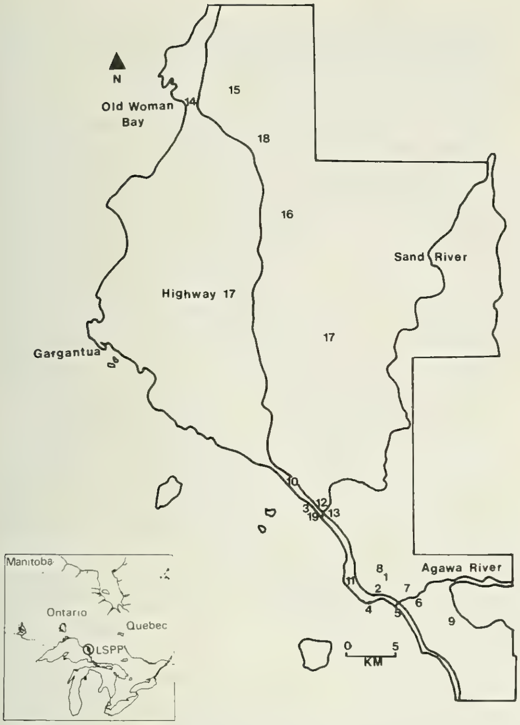

FIGURE 1. Map of Lake Superior Provincial Park showing its position in Ontario and approximate locations of traplines.

Department of Mammalogy, ROM). Unsalvageable and unidentifiable specimens were discarded.

Since our traplines contained only two kinds of traps, fossorial and volant mammals (Talpidae and Vespertilionidae) were underrepresented in our survey. Owing to the mole's adaptation to life almost exclusively in soil and the fact that adult moles tend to avoid pitfall-type traps, special mole traps are necessary in order to to obtain better estimates of abundance and distribution of talpids (Rudge 1966). Similarily, our survey was biased against bats since neither snap traps nor pitfalls catch these flying mammals.

Results

The 19 traplines yielded 890 small mammals representing five species of shrews (Soricidae), one species of mole (Talpidae), three species of squirrels (Sciuridae), five species of mice, voles, lemmings (Cricetidae) and two species of jumping mice (Zapodidae) [Table 2]. Additional incidental specimens included *Myotis lucifigus* (Little Brown Bats, netted) *Lepus americanus* (Snowshoe Hare), *Tamias striatus* (Eastern Chipmunk), *Tamiasciurus hudsonicus* (Red Squirrel) (all obtained with a .410 shotgun), *Vulpes vulpes (Red Fox), Mustela vison* (Mink) (both roadkills), *Glaucomys sabrinus* (Northern Flying Squirrel), and *Peromyscus maniculatus* (Deer Mouse) (found at campsites) [Table 3]. In total 932 individuals were recorded.

TABLE 1. Location of 19 traplines set in six different vegetation zones of Lake Superior Provincial Park.

Vegetation Zones	Traplines	Location	Description
Coastline	3	84°44′N 47°26′W	sand dune habitat
	19	″ ″	″ ″
	14	84°54′N 47°47′W	rocky shoreline
Boreal Forest	10	84°46′N 47°28′W	Eastern White Cedar-Black Spruce forest
	12	84°44′N 47°26′W	Black Spruce forest
	13	84°43′N 47°26′W	″ ″
	15	84°52′N 47°48′W	mixed boreal forest
	18	84°49′N 47°45′W	″ ″
Wetlands	5	84°35′N 47°20′W	wet meadow
	9	84°34′N 47°20′W	″ ″
	17	84°43′N 47°36′W	Black Lake fen habitat
Southern Deciduous Forest	1	84°38′N 47°22′W	Sugar Maple forest
	8	84°31′N 47°23′W	″ ″ ″ ″ ″
	6	84°34′N 47°21′W	Sugar Maple/Yellow Birch forest
	7	84°38′N 47°22′W	″ ″ ″ ″ ″
	2	84°38′N 47°21′W	Eastern White Cedar ridge forest
Southern Coniferous Forest	4	84°40′N 47°21′W	coniferous pine parkland
	11	84°42′N 47°22′W	″ ″ ″
River Lowland	16	84°47′N 47°42′W	grass/shrub river shoreline

TABLE 2. Total number of small mammals (n = 890) collected from 19 traplines in LSPP (1983–1985).

	Trapline number																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	%
S. palustris		1				1														0.3
S. cinereus	16	4	3	1	2	8	7	17	9	11		19	1	4	3	8	31	1	3	16.6
S. fumeus	1	17	6	9		9	4				3	3	7	10	7	1	1	5		9.3
S. hoyi									1	1		2	2	2			5	4	2	2.1
B. brevicauda						2	2	1		1		4					1	3	6	2.2
C. cristata								1										1		0.2
P. maniculatus	49	55	38	18	4	35	4	5		3	2	3	2	52	9		13	15	62	41.5
C. gapperi	6	9		3	1	5	6	5		1	4	17	15	8	28		29	4	3	16.2
S. cooperi					1					1										0.2
M. pennsylvanicus					2		1		5								16	1		2.8
M. chrotorrhinus	1						2	2												0.6
Z. hudsonius						1			6					1		7	4		2	2.4
N. insignis	5		4			10	3						1	1					1	2.8
T. striatus			1		1									2	1				13	2.0
E. minimus				1															1	0.2
G. sabrinus						1													3	0.5
Subtotal	78	86	52	32	11	72	29	31	21	18	9	48	28	80	48	16	101	34	96	100

P. maniculatus was the most abundant small mammal trapped, constituting approximately 42% of all captures, followed by *S.cinereus* (17%), *C. gapperi* (16%), and *S. fumeus* (9%). *Sorex hoyi* (Pygmy Shrew), *Blarina brevicauda* (Short-tailed Shrew), *Microtus pennsylvanicus* (Meadow Vole), *Zapus hudsonius* (Meadow Jumping Mouse), *Napaeozapus insignis* (Woodland Jumping Mouse), and *T. striatus* each made up approximately 2% of total captures. The least common species, each of which made up less than 1% of the total catch, were *Sorex palustris* (Water Shrew), *Condylura cristata* (Star-nosed Mole), *Synaptomys cooperi* (Southern Bog Lemming), *Microtus chrotorrhinus* (Rock Vole), *Eutamias minimus* (Least Chipmunk), and *G. sabrinus* (Table 2).

Since the number of traps, trap nights, and sampling effort were identical for each trapline, the number of captures gives an index of comparative abundance. However, factors such as different sizes of home ranges, different foraging strategies, behavioral differences, weather during trapping periods all influence trapping success and therefore this index can not serve as an absolute estimate of relative abundance.

Values for the 16 species trapped is summarized in Table 4. Small mammal abundance within the six vegetation zones was highest in the southern deciduous forest, followed by the coastline habitats, wetlands, and boreal forest. Traplines set in the southern coniferous forest and river lowland showed the lowest abundance and species diversity (Table 4).

Small mammals were considered as belonging to one of three trophic groups: *S. cinereus, S. palustris, S. hoyi, S. fumeus, B. brevicauda,* and *C. cristata* were classified as insectivores; *M. pennsylvanicus, M. chrotorrhinus*, and *S. cooperi* as herbivores; *C. gapperi, P. maniculatus, N. insignis, Z. hudsonius, T. striatus, E. minimus,* and *G. sabrinus* as omnivores. The abundance and distribution of trophic groups varied from one plant community to another: omnivores were most abundant in the three forest, wetland and coastline communities, insectivores were most abundant only in the river lowland, and herbivores were present in three habitats — the wetlands (18%), southern deciduous forest (2%), and in the boreal forest (1.4%).

Discussion

Abundance and species diversity in different plant communities of LSPP

The four most abundant small mammals in LSPP were *P. maniculatus, C. gapperi, S. fumeus,* and *S. cinereus*, representing 83.6% of total captures. In the three forest communities, *P. maniculatus* and *C. gapperi* were the most numerous omnivores, while *S. fumeus* and *S.*

TABLE 3. Twenty-one species of small mammals collected during three summers of field work (1983–85) at LSPP.

Species	Year			Total Number
	1983	1984	1985	
Sorex cinereus	34	64	50	148
Sorex fumeus	43	17	24	84
Sorex hoyi	0	6	13	19
Sorex palustris	2	0	1	3
Blarina brevicauda	2	8	10	20
Condylura cristata	0	1	1	2
Tamiasciurus hudsonicus	0	2	0	2
Tamias striatus	2	2	16	20
Eutamias minimus	1	1	1	3
Glaucomys sabrinus	1	0	5	6
Peromyscus maniculatus	200	19	151	370
Clethrionomys gapperi	23	48	72	143
Synaptomys cooperi	1	1	0	2
Microtus pennsylvanicus	2	6	17	25
Microtus chrotorrhinus	1	4	0	5
Zapus hudsonius	1	6	14	21
Napaeozapus insignis	18	4	2	24
Myotis lucifugus	32	0	0	32
Lepus americanus	1	0	0	1
Vulpes vulpes	1	0	0	1
Mustela vison	0	0	1	1
Total	365	189	378	932

TABLE 4. Relative abundance (expressed as total captures/100 trap nights/species) of 16 different species of small mammals collected from LSPP (1983–85).

Species	Vegetation zones					
	Coastline	Boreal forest	Wetlands	S. Deciduous forest	S. Coniferous forest	River lowland
Sorex palustris			0.08	0.10		
Sorex cinereus	0.83	1.75	3.5	2.6	0.13	2.0
Sorex fumeus	1.33	1.10	0.08	1.6	1.5	0.25
Sorex hoyi	0.33	0.45	0.50			
Blarina brevicauda	0.50	0.40	0.08	0.25		
Condylura cristata		0.50		0.05		
Peromyscus maniculatus	12.7	1.60	1.42	7.4	2.5	
Clethrionomys gapperi	0.92	3.25	2.5	1.55	0.88	
Synaptomys cooperi		0.05	0.8			
Microtus pennsylvanicus		0.05	1.92	0.05		
Microtus chrotorrhinus				0.25		
Zapus hudsonius	0.25		0.83	0.05		1.75
Napaeozapus insignis	0.50	0.05		0.96		
Tamias striatus	1.33		0.08		0.13	
Eutamias minimus	0.08				0.13	
Glaucomys sabrinus	0.25			0.05		
Total catch/100 TN	19.02	8.8	11.1	19.4	5.25	4.0
Total trap nights	1200	2000	1200	2000	800	400
Number of traplines	3	5	3	5	2	1
Total specimens	228	175	133	296	42	16
Number of species	11	10	11	12	5	3

cinereus were the most abundant insectivores. *P. maniculatus* and *T. striatus* were trapped in greatest numbers along the coast, and the most abundant insectivores were *S. fumeus* and *S. cinereus*. The largest numbers of *M. pennsylvanicus* were found in the wetlands, which also supported a high population of *S. cinereus* and *C. gapperi*. The river lowland was poorest in both abundance and diversity of species.

According to Miller and Getz (1977), the distribution, abundance and species diversity of mammals can be closely correlated with environmental factors such as food resources, topography, temperature, vegetation types and cover. Quetico Provincial Park (QPP), located west of LSPP, is also part of the Great Lakes-St. Lawrence Forest Region (Beechey 1972. Ecological Inventory of Lake Superior Provincial Park. OMNR; Rowe 1972). The similarities in environmental conditions and habitats of the two parks are reflected in the similarities of small mammal species found in each park [a more detailed description of habitats sampled and mammals collected from QPP is given in Nagorsen and Peterson (1981)]. *C. gapperi, P. maniculatus*, and *S. cinereus* are the three most abundant species in both Parks. In QPP, they constitute 86% of all captures, and in LSPP, 74%.

Both *P. maniculatus* and *C. gapperi* are omnivorous; their broad diet consists of different invertebrates and a variety of plant species (Merritt and Merritt 1978), foods which appear to be abundant in forests of both parks. Krebs and Wingate (1976) reported the dominance of these two omnivores in other boreal forests as well. *S. cinereus* is the dominant insectivore in both parks. Vegetation type, food, cover, high moisture levels and snow cover greatly influence the diet and abundance of shrews (Wrigley et al. 1979).

Both LSPP and QPP show a similar pattern in the structure of their trophic communities. Omnivores account for the greatest percentage of total captures, while herbivores constitute the smallest capture. Since the latter trophic group requires abundant herbaceous cover associated with grassland habitats (Grant and Birney 1979) or wetland communities (Gibson and Peterson 1982; Nagorsen 1982), it is not surprising that few specimens were caught.

Miller and Getz (1977) found a correlation between mammal species diversity and diversity of vegetation and consider availability of food to be a primary factor affecting diversity of small mammals in forested regions. Using Beechey's (1972. Ecological Inventory of Lake Superior Provincial Park. OMNR) detailed description of the vegetation of LSPP in conjunction with our survey, we noted obvious differences in the distribution and abundance of different trophic groups of small mammals in various habitats. The greatest total catch and the largest number of small mammal species were obtained from the southern deciduous forest, with highest apparent diversity of vegetation, and coastline and wetland habitats which were bordered by forests. The boreal forest, with less tree species diversity, but with diverse lush ground vegetation, also supported many species of mammals. The southern coniferous forest and river lowland, with less tree and ground plant diversity, produced the smallest total catch and had the lowest diversity of small mammals. Our results agree with those of Miller and Getz (1977) in that abundance and number of different species increased with vegetation diversity.

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Comportement des larves d'éperlan, *Osmerus mordax*, en fonction de l'intensité lumineuse, du courant d'eau et du type de nourriture

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Bédard, Dany, et Louis-Marie Lalancette. 1989. Comportement des larves d'éperlan, *Osmerus mordax*, en fonction de l'intensité lumineuse, du courant d'eau et du type de nourriture. Canadian Field-Naturalist 103(1): 75–79.

La présence de nourriture n'est pas un facteur suffisant ($P < 0,05$) pour déclencher le comportement de nutrition des larves d'éperlan, *Osmerus mordax*. Le courant d'eau et principalement l'intensité lumineuse ont une importance significative sur l'activité et le comportement alimentaire des larves. Elles présentent un fort comportement de phototaxie positive. D'ailleurs, à forte intensité lumineuse, les larves se concentrent essentiellement près de la surface de l'eau et l'effet du courant sur le pourcentage de larves en mouvement n'est pas significatif. Leurs comportements d'orientation et d'alimentation sont plus intenses en présence d'un courant d'eau, d'une intensité lumineuse de 17 000 1x et d'une nourriture additionnée de bétaine, L-alanine et L-arginine à 10 mmol.l^{-1}.

The presence of food is not an important factor ($P < 0.05$) in initiating feeding behaviour in the larvae of the Rainbow Smelt, *Osmerus mordax*. Water current, and, especially, light intensity, do have an important effect on their activity and feeding behaviour. The larvae show strong positive phototaxis. Moreover, at high light intensities they concentrate primarily near the water surface and the effect of current on the percentage of larvae in motion is not significant. Their orientation and feeding behaviour are more intense in the presence of a water current, light intensities of 17 000 1x and of food supplemented with betaine, L-alanine and L-aringine at a concentration of 10 mmol.1-1.

Key Words: Eperlan, *Osmerus mordax,* Rainbow Smelt, light, food, current, feeding, nourriture, intensité lumineuse, courant, comportement alimentaire.

Des tentatives d'élevages de larves d'éperlans, *Osmerus mordax*, ont été effectuées par Akielaszek et al. (1985) et Cooper (1978), mais les résultats escomptés n'ont pas été atteints suite à une mortalité massive des larves lors du passage d'une nutrition endogène à exogène. Cette transition de la nutrition endogène à exogène, au cours du développement larvaire, est considérée comme étant une période critique pour la survie des larves de poissons (Eldridge et al. 1981; Wiggins et al. 1985).

Le succès de culture de plusieurs espèces de poissons est généralement dépendant de cette transition (Malhotra et Munski 1985; Wiggins et al. 1985). Kinne (1977) mentionne que plusieurs larves refusent de se nourrir quand elles ne rencontrent pas certaines conditions bien spécifiques: courant d'eau, intensité lumineuse et grosseur des aliments ingérés. Kiyono et Hirano (1981) ont montré que la consommation de nourriture et la croissance en longueur de *Mylio macrocephalus* était plus grande à 30 000 1x.

Dabrowski (1984) mentionne que des caractéristiques spécifiques sont requises pour que les larves de poissons se nourrissent, soit le goût et la grosseur des aliments, auxquels s'ajoutent des facteurs abiotiques. D'ailleurs, Caprio (1982) mentionne la réponse élevée des récepteurs gustatifs du poisson-chat à la L-alanine et à la L-arginine à 10^{-2}mmol.l^{-1}. Carr (1982) ajoute que la bétaine, en présence d'autres acides aminés, contribue à une amplification du comportement de nutrition. De plus, Corazza et Nickum (1981) mentionnent que les facteurs modifiant le comportement de nutrition des larves affectent leurs autres comportements et leur survie, ce qui est d'une importance déterminante pour leur élevage en pisciculture.

Une meilleure connaissance de la biologie des larves d'éperlan arc-en-ciel est donc nécessaire si on veut entreprendre l'élevage de cette espèce en pisciculture. C'est pourquoi nous avons décidé d'étudier le comportement des larves d'éperlan, *Osmerus mordax,* en fonction de l'intensité lumineuse, de la vitesse du courant d'eau et du type de nourriture.

Matériel et méthodes

L'étude a porté sur des larves encore dotées de leur sac vitellin et a débuté à la journée suivant l'éclosion, soit à l'ouverture de la bouche. Sept groupes de 50 larves ont été étudiés en milieu fermé, dans des réservoirs cylindriques de 500 m*l* d'une profondeur de 8 cm, dont la moitié du volume d'eau était renouvelée à chaque 12 heures. On a utilisé l'eau municipale de Chicoutimi, préalablement filtrée à travers du charbon activé et des filtres millipores de 5 et 15 μm, puis recirculée dans des tubes de verre sous ultraviolets. Une pierre millipore à bullage placée dans chacun des réservoirs a servi à oxygéner le milieu. L'expérience a duré trois jours et la température de l'eau s'est située entre 9 et 12°C.

La profondeur des bassins se partageait en trois sections égales et on a noté, lors des séances d'observation, l'endroit où plus de 50% des larves se situaient, d'aprés les indices suivants: 2) fond, 4) milieu ou 6) surface de l'eau. De même, on a noté de façon qualitative la présence d'orientation et la prise d'aliments chez plus de 50% des larves en mouvement lorsqu'on distribuait la nourriture dans un coin du réservoir, selon les indices suivants: 0) aucune orientation ni alimentation, 1) aucune alimentation mais orientation, 2) orientation et alimentation d'une durée de moins de 5 min., 3) orientation et alimentation plus de 5 min. Le pourcentage des larves en mouvement (nage active) a été évalué selon les indices suivants: 1) 0-19%, 2) 20-39%, 3) 40-59%, 4) 60-79% et 5) 80-100% de larves en mouvement.

Les larves furent alimentées avec de la moulée d'omble de fontaine en provenance de Nutribec Ltée., sans addition d'acides aminées, à l'exception du 7 septième groupe (G), qui fut alimenté avec une moulée enrichie de trois acides aminés. La moulée sèche avait tendance à sédimenter suite à sa distribution à la surface de l'eau. Elle fut broyée puis homogénéisée pour donner deux parties de 500 m*l*: une partie fut mélangée avec 75 m*l* d'eau distillée et l'autre, avec 75 m*l* d'eau distillée additionnée de L-arginine, de L-alanine et de bétaine, à une concentration de 10 $\text{mmol.}l^{-1}$. Après séchage à une température de 60° C durant 12 h, la moulée fut tamisée en vue d'obtenir des particules alimentaires de 125 à 250 μm. Par ailleurs, on a mesuré des larves *d'Artemia salina* nouvellement écloses pour évaluer si elles pouvaient éventuellement être distribuées comme nourriture aux larves d'éperlan dès le stade de l'ouverture de la bouche.

Chaque groupe de larves fut observée cinq fois par jour pendant 10 minutes lors de chaque période d'alimentation, soit 5 min. d'observation avant et 5 min. pendant l'alimentation. Les indices ont été notés à toutes les 20 sec. au cours des périodes d'observations. Les groupes furent exposés à une photopériode de 16:8 d^{-1} et maintenus à une intensité lumineuse de 500 1x à la surface de l'eau, en dehors des périodes d'alimentaiton. L'éclairage provenait de tubes fluorescents clairs et l'intensité lumineuse désirée fut obtenue par leur éloignement ou leur rapprochement par rapport à la surface des bassins. Ces derniers furent peints en noir avec de la peinture époxy afin d'augmenter le contraste entre les particules alimentaires et les parois.

Lors des périodes d'alimentation, les groupes de larves A, B et C ont été soumis à une vitesse de courant nulle et à des intensités lumineuses respectives de 500, 2 000 et 17 000 1x à la surface de l'eau. Les groupes de larves D, E et F ont été exposés à une vitesse de courant de 30 à 70 mm.s^{-1}, à l'aide d'une pierre millipore, et à des intensités lumineuses respectives de 500, 2 000 et 17 000 1x à la surface de l'eau. L'augmentation de l'intensité lumineuse s'est faite en une seule séquence. Quant au groupe G, il a été soumis à une vitesse de courant de 30 à 70 mm.s^{-1} et à une intensité lumineuse de 500 1x.

Résultats

Larves en mouvement

Le tableau 1 donne les indices moyens correspondant aux pourcentages de larves de chaque groupe en mouvement selon la vitesse du courant et l'intensité lumineuse. Les résultats d'analyse statistique obtenus chez les larves en mouvement du groupe A, avant et durant l'expérimentation, ne diffèrent pas (t = 1,18; $P > 0{,}05$), ce qui signifie que la présence de nourriture seule n'augmente pas le pourcentage des larves en mouvement.

La comparaison entre les milieux à eau calme et à courant, sous une intensité lumineuse de 500 1x avant alimentation, montre que plus de larves se

TABLEAU 1. Indices moyens correspondant aux pourcentages de larves d'*Osmerus mordax* en mouvement selon l'intensité lumineuse et la vitesse du courant.

Groupe de larves	Vitesse du courant (mm·s^{-1})	Indices du pourcentage de larves en mouvement				
		1ère séance à 500 lx		2e séance		
		I	σ	I	σ	intensité lumineuse (lx)
A	0	1,10	0,327	1,13	0,221	500
B	0	1,07	0,389	1,48	0,114	2 000
C	0	1,16	0,452	4,38	0,209	17 000
D	30-70	1,38	0,201	1,44	0,192	500
E	30-70	1,47	0,148	2,02	0,114	2 000
F	30-70	1,36	0,200	4,79	0,100	17 000

σ: écart-type.
I: indice moyen.

TABLEAU 2. Indices moyens correspondant à la position des larves d'*Osmerus mordax* dans la colonne d'eau selon l'intensité lumineuse et le courant d'eau.

Intensité lumineuse (1x)	Vitesse du courant ($mm \cdot s^{-1}$)	
	0	30-70
500	2,00 (0,000)	2,13 (0,333)
2 000	2,06 (0,174)	2,17 (0,282)
17 000	6,00 (0,000)	6,00 (0,000)

Les nombres entre parenthèses indiquent l'écart-type (σ).

meuvent en eau courante ($t = 17{,}39$; $P < 0{,}05$). L'analyse statistique a fait ressortir une différence significative ($t = 2{,}50$; $P < 0{,}05$) entre les pourcentages de larves en mouvements du groupe D avant et pendant l'expérimentation. Ainsi, la présence de nourriture dans un milieu à eau courante semble avoir stimulé l'activité des larves, mais cette activité était toutefois faible comparativement à celle observée aux intensités lumineuses supérieures, comme le témoignent les valeurs du test de Student.

Pour le groupe E, on a calculé un t égal à 44,9 ($P < 0{,}01$) et pour le groupe F, un t de 217,05 ($P < 0{,}01$). Ces valeurs montrent l'importance de l'intensité lumineuse pour l'activité des larves. D'ailleurs, une analyse de variance à deux facteurs (soit l'intensité lumineuse et le courant) a révélé des écarts significatifs du pourcentage de larves en mouvement entre l'intensité lumineuse ($F = 1022{,}84$; $P < 0{,}05$), qui est le plus important des facteurs abiotiques, et le courant ($F = 41{,}75$; $P < 0{,}05$).

De même, l'analyse de variance a révélé que l'intensité lumineuse ($F = 3991{,}1$; $P < 0{,}05$) avait un rôle stimulateur plus important que le courant ($F = 3{,}9$; $P < 0{,}05$) sur la position des larves dans la colonne d'eau (tableau 2). Le test de Student a montré un écart significatif de la position des larves dans la colonne d'eau aux intensités lumineuses de 500 1x ($t = 8{,}46$; $P < 0{,}05$) et de 2 000 1x ($t = 7{,}12$; $P < 0{,}05$), entre le milieu lentique et le milieu lotique. Aucun écart significatif ($t = 0{,}00$; $P > 0{,}05$) n'a été enregistré à une intensité lumineuse de 17 000 1x. Le courant paraît donc avoir eu un effet sur la position des larves à faible intensité lumineuse.

Orientation et alimentation des larves

Le tableau 3 présente le comportement d'alimentation et d'orientation des larves selon l'intensité lumineuse et le courant. Une analyse de variance a permis de constater une différence significative du comportement des larves selon l'intensité lumineuse en eau calme ($F = 631{,}32$; $P < 0{,}05$) et dans le curant ($F = 327{,}57$; $P > 0{,}05$). Ces valeurs démontrent qu'en eau calme, l'intensité lumineuse avait un plus grand effet sur le comportement d'alimentation. Le test de Student a révélé un écart significatif du comportement d'alimentation des larves à 500 1x entre les milieux lentique et lotique ($t = 8{,}45$; $P < 0{,}05$); il en fut de même à 2 000 1x ($t = 7{,}12$; $P < 0{,}05$). À 17 000 1x, il n'y avait aucun écart significatif du comportement d'alimentation en fonction du courant d'eau ($t = 0{,}00$; $P > 0{,}05$).

Selon les types de nourriture, les larves ont montré un comportement alimentaire plus important ($t = 2{,}11$; $P < 0{,}05$) avec la moulée enrichie des trois acides aminés suivants: L-alanine, L-arginine et bétaine (10 $mmol.l^{-1}$).

Le tableau 4 donne la dimension de la bouche des larves d'éperlans au deuxième jour après l'éclosion, et les dimensions d'*Artemia salina* nouvellement écloses. On constate que la largeur moyenne de la bouche des larves est plus petite que la longueur et la largeur avec antennes des larves d'*Artemia salina* nouvellement écloses.

Discussion

Nos résultats semblent démontrer que la seule présence de nourriture n'est pas suffisante pour déclencher le réflexe de nutrition chez les larves. Kinne (1977) mentionne à ce sujet que les larves

TABLEAU 3. Indices moyens correspondant au comportement d'alimentation et d'orientation des larves d'*Osmerus mordax*, selon la vitesse du courant et l'intensité lumineuse.

Courant d'eau ($mm \cdot s^{-1}$)	Intensité lumineuse (1x)		
	500	2 000	17 000
0	0,30 (0,461)	0,90 (0,366)	2,70 (0,541)
30-70	0,50 (0,503)	1,00 (0,410)	2,65 (0,631)

Les nombres entre parenthèses indiquent l'écart-type (σ).

TABLEAU 4. Largeur de la bouche (mm) des larves d'*Osmerus mordax* et dimensions des larves d'*Artemia salina* (mm) nouvellement écloses.

	M	σ	N
Largeur de la bouche des larves d'éperlans:	0,230	0,041	10
Dimensions des larves d'*Artemia salina*			
longueur	0,413	0,042	10
largeur sans antenne	0,187	0,029	10
largeur avec antenne	0,466	0,033	10

M: moyenne.
σ: écart-type.
N: nombre d'individus.

doivent rencontrer des conditions spécifiques: taille des aliments, photopériode, température, courant d'eau, intensité lumineuse, etc. Selon Hyatt (1979), la localisation de la nourriture dépend de stimuli sensoriels, visuels, électriques, mécaniques et chimiques. Il va sans dire qu'une connaissance des facteurs abiotiques est primordiale si on veut entreprendre des élevages en pisciculture.

Le rôle de l'intensité lumineuse dans l'activité et le comportement alimentaire des larves d'éperlans est important. Kiyono et Hirano (1981) et Hinshaw (1985) ont démontré qu'une grande intensité lumineuse augmentait la survie et la croissance des larves. Flütcher (1980) a noté qu'une itensité lumineuse supérieure à 20 000 1x avait comme effet de stimuler la recherche de la nourriture chez le corégone, *Coregonus lavaretus*. D'après nos résultats, le maintien des larves dans la colonne d'eau est principalement dû à l'intensité lumineuse. À forte intensité lumineuse (17 000 1x), les larves se sont concentrées à la surface. Nous avons constaté leur rapidité et leur vigueur face à la nourriture à la surface. Selon Corazza et Nickum (1981), lorsque la distance entre le prédateur et la proie est minimisée, le temps de capture et de consommation de la particule alimentaire seront diminués et l'efficacité de nutrition augmentée.

De même, nous avons observé que l'intensité lumineuse reste un facteur abiotique plus important que le courant d'eau pour l'activité et le comportement alimentaire des larves d'*Osmerus mordax*. À faible intensité lumineuse (500 et 2 000 1x), une circulation de l'eau dans le milieu augmente le pourcentage de larves en mouvements et le déplacement des particules alimentaires stimule le comportement de nutrition des larves. Les résultats peuvent être influencés par la photopériode imposée et par le microbullage. Puisque ceux-ci furent constants entre les différents milieux, on assume que les différences enregistrées sont réelles.

Kinne (1977) et Hyatt (1979) mentionnent que le mouvement de la nourriture peut être important pour son acceptation. Le va-et-vient de la nourriture semble effectivement avoir eu un effet positif sur le comportement des larves, à faible intensité lumineuse. Le courant empêchait les particules de nourriture de se déposer au fond du bassin. Ainsi, ce brassage des particules alimentaires a rendu la nourriture disponible plus longtemps, et plus accessible aux larves à l'intérieur de la colonne d'eau.

Hartmann (1983) estime que la survie des larves de poissons dépend du mode de nutrition, de la largeur de la bouche, de la grosseur et de la disponibilité de la nourriture. Puisqu'au deuxième jour, la largeur de la bouche est en moyenne de 230 μm, valeur inférieure à la dimension d'une larve nouvellement éclose de nauplie, *Artemia salina*. Cooper (1978) a d'ailleurs tenté sans succès de nourrir des larves d'*Osmerus mordax* à partir de nauplies nouvellement écloses. De leur côté, Dabrowski et Bardega (1984) ont fait plusieurs observations et mentionnent que les dimensions des proies ne doivent pas excéder 0,8 fois la grandeur de la bouche des larves de poissons.

Enfin, Dabrowski (1984), Hyatt (1979) et Atema et al. (1980) ont démontré l'importance de la saveur de la nourriture pour son acceptation par les larves de poissons. Il semble que la présence de certains acides aminés stimule leur comportement alimentaire (Dabrowski 1984). Or, avec une moulée enrichie de trois acides aminés, soit la L-alanine, la L-arginine et la bétaine, à une concentration de 10 mmol $\cdot l^{-1}$, nos larves ont montré un comportement d'orientation plus prononcé qu'avec une nourriture sans aucune addition d'acides aminés.

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A Meristic, Morphometric and Electrophoretic Analysis of Cutthroat Trout, *Salmo clarki*, from Two Mountain Lakes in Alberta

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Meristic, morphometric and electrophoretic data were compiled on two populations of Cutthroat Trout (*Salmo clarki*) in Alberta lakes to determine their taxonomic status. Results showed both populations were Westslope Cutthroat Trout (*Salmo clarki lewisi*) with no introgression from other sub-species or Rainbow Trout (*Salmo gairdneri*). The Job Lake stock differed significantly from the Picklejar Lake population. The lack of allelic variability in the Job Lake population is a cause for concern because it may result in poor performance by hatchery progeny when stocked in other waters. The Picklejar Lake population complex is a rare example of shoal-spawning Westslope Cutthroat Trout, which should be protected from overexploitation.

Key Words: Cutthroat Trout, *Salmo clarki*, Westslope strain, meristics, morphometrics, electrophoretics, Alberta.

Following the establishment of a fish hatchery at Banff, Alberta, in 1913, widespread stocking of trout occurred in streams of the east slopes of the Rocky Mountains in Alberta. Rainbow Trout (*Salmo gairdneri*), Yellowstone Cutthroat Trout (*S. clarki bouvieri*), Westslope Cutthroat Trout (*S. clarki lewisi*), hybrid trout (*Salmo clarki* x *Salmo gairdneri*), Brook Trout (*Salvelinus fontinalis*), Brown Trout (*Salmo trutta*), Lake Trout (*Salvelinus namaycush*) and Golden Trout (*Salmo aguabonita*) have been stocked in lakes and streams of the area, often without any written record (Nelson 1965). Native Westslope Cutthroat Trout have been extirpated from much of their historical range in Alberta and elsewhere and have also hybridized with Rainbow Trout and Yellowstone Cutthroat Trout. There is therefore concern about the present status of the native Westslope Cutthroat Trout in Alberta.

The purpose of this study was to determine whether Job Lake and Picklejar Lake #4 contain pure Westslope Cutthroat Trout populations. The status of the Job Lake population is important because it is the source of eggs for the Cutthroat Trout stocking program being used to reintroduce Cutthroat Trout in Alberta waters. Job Lake was barren of fish until 1965 when it was stocked with Westslope Cutthroat Trout from Marvel Lake, Alberta (McAllister et al. 1981). From that planting, a viable reproducing population has established itself in Job Lake that supports a moderate sport fishery. Approximately 300 000 cutthroat eggs are taken each year from the population by Alberta Fish and Wildlife Division hatchery personnel.

Picklejar Lake #4 is the lowermost of four adjacent, consecutively numbered lakes from upstream to downstream situated in southwestern Alberta (Figure 1). Cutthroat Trout are present only in the second and fourth lakes. As there are no records of trout stocking in any of the Picklejar Lakes, it was thought that the Cutthroat Trout were native to Lake #4 as well as Lake #2. The concern here is that angling on this small lake could reduce the population to the point where it is no longer viable as a genetic stock. Therefore, a hypothesized unique stock of fish would be lost through extirpation or dilution with hatchery fish. R. Behnke (Colorado State University (CSU), Fort Collins, Colorado, personal communication) had collected fish from Picklejar Lake #2 in 1957 and concluded, on the basis of meristic counts, that they were pure Westslope Cutthroat Trout. Because of this, Picklejar Lakes were closed to angling from 1971 to 1985 to protect the fish populations until more definite studies could be undertaken to determine whether the lakes contained a pure strain of native Cutthroat Trout.

Several measures were used to determine the genetic status of these populations. Counts and measurements of body parts were made. Certain of these characteristics are believed to be almost totally under genetic control in other salmonids and are therefore assumed to be useful for comparison with other Cutthroat Trout strains and Rainbow Trout (Svardson 1952; Riddel et al.

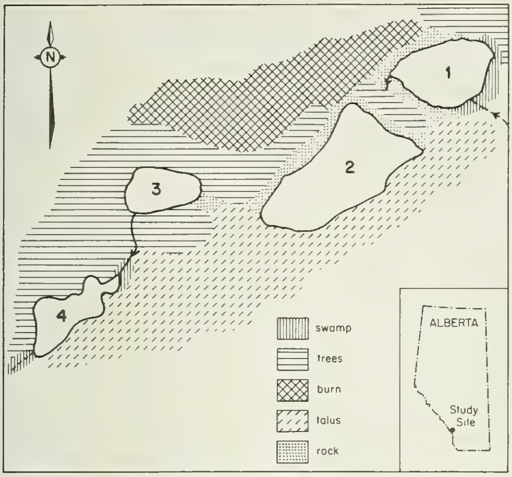

FIGURE 1. Map showing the location of the Picklejar Lakes study site in Alberta (inset) and the surrounding habitat and the relative positions and sizes of Picklejar Lakes 1-4.

1981). The trout were then characterized electrophoretically and these data were compared to data from Rainbow Trout and other populations of Cutthroat Trout (Loudenslager and Kitchen 1979; Allendorf and Phelps 1980; Loudenslager and Gall 1980; Campton and Utter 1985). Westslope Cutthroat Trout have unique alleles at several loci that make it possible to distinguish hybrids with other strains and Rainbow Trout.

Methods and Materials

Job Lake (North Saskatchewan River Basin; 52° 22′ N, 116° 51′ W) and Picklejar Lake #4 (Bow River Basin; 50° 13′ N, 114° 47′ W) are high mountain lakes at elevations of 2049 and 2149 m, respectively. Job Lake covers 48 ha and has a maximum depth of 25 m. Picklejar Lake #4 covers 1.6 ha and has a maximum depth of 1.5 m.

Whole fish samples for meristic, morphometric and electrophoretic analyses were collected from Picklejar Lake #4 on 10 August 1983 by angling, and during the egg take at Job Lake in June 1983 using a 15.5-m hand seine. Samples were put on ice upon collection and through shipment and stored frozen up to four months.

A total of 42 individuals from Job Lake and 67 individuals from Picklejar Lake #4 were analysed. Horizontal starch-gel electrophoresis was performed on centrifuged eye, heart and muscle material following procedures outlined in Utter et al. (1974) and May et al. (1979). Three buffer systems were used (Markert and Faulhaber 1965; Ridgeway et al. 1970; Clayton and Tretiak 1972). The gels were stained as indicated in Harris and Hopkins (1976) and Allendorf et al. (1977). A total of 31 enzymes encoded by 55 loci were scored (Table 1).

Morphometric measurements and meristic counts were made following Hubbs and Lagler (1958) [Table 2]. A total of seven measures and nine counts were made on the fish samples from Picklejar Lake #4 (Table 2).

Results and Discussion

The pyloric caeca count, two scale counts and the percentage of fish with basibranchial teeth from Picklejar Lake #4 were very similar to the 1957 sample from Picklejar Lake #2 (R. Behnke, CSU, Fort Collins, Colorado, personal communication) and indicate, as expected, a close genetic relationship. These two lakes have been isolated from each other since a rock slide blocked the outlet from Picklejar Lake #2 (Figure 1). It is not known how long the blockage has been present, but there is no historical record of the outlet stream flowing.

A comparison between measures for Picklejar Lake #4 and Marvel Lake (McAllister et al. 1981) reveals differences between the two populations with three out of four counts significantly different ($P = 0.05$) [Table 2]. The number of pyloric caeca and scales above the lateral line were both lower in the Picklejar Lake #4 fish while the lateral line scale count was significantly higher than the Marvel Lake fish ($P = 0.05$) [Table 2]. This suggests that the two populations, and by inference the Job Lake fish, have been isolated from each other for some time.

The pyloric caeca counts for Picklejar Lake #4 fish were at the low end of the range for Westslope Cutthroat Trout, and much lower than Yellowstone Cutthroat Trout or Rainbow Trout (Table 3). The gill raker counts were low compared to Yellowstone Cutthroat Trout, and both scale counts were higher than the typical value for Rainbow Trout. These data are in agreement with the Picklejar Lake #4 population's being a pure strain of Westslope Cutthroat Trout, with little or no introgression with Rainbow Trout or other subspecies of Cutthroat Trout.

Of the 55 loci resolved, *MDH-1* was the only locus polymorphic and just in the Job Lake fish. No variation was found in the Picklejar Lake #4 samples. All individuals from both populations showed the Westslope Cutthroat Trout common alleles at the characteristic loci of *ME-1,3 GPI-3,* and *IDH-3,4* (Reinitz 1977; Loudenslager and Gall 1980). These electrophoretic results categorically

TABLE 1. Designation of loci coding for the different enzymes and proteins stained for Cutthroat Trout in this study. Abbreviations and enzyme commission numbers are also given. Multiple loci are designated in brackets after the enzyme.

Enzyme	Abbreviation	Enzyme Commission number
Aconitase	ACO	4.2.1.3
Adenosine deaminase	ADA	3.5.4.4
Alcohol dehydrogenase	ADA	1.1.1.1
Creatine kinase (1,2)	CK	2.7.3.2
Esterase (1-3)	EST	3.1.1.1
Fumarase	FUM	4.2.1.2
B-Galactosaminidase	BGAM	
B-Glucoseaminidase	BGLUM	
Glucose phosphate isomerase (1-3)	GPI	5.3.1.9
Glutathione reductase	GR	1.6.4.2
Clyceradehyde phosphate dehydrogenase	GAP	1.2.1.12
Glycerol-3-phosphate (1-4)	AGPD	1.1.1.8
Glyoxylase I	GLOI	3.1.2.6
Glyoxylase II	GLOII	3.1.2.6
Guanine deaminase	GDA	3.5.4.3
Hexokinase	HK	2.7.1.1
Isocitrate dehydrogenase (1-4)	IDH	1.1.1.42
Lactate dehydrogenase (1-5)	LDH	1.1.1.27
Malate dehydrogenase (1-4)	MDH	1.1.1.37
Malic enzyme (1-3)	ME	1.1.1.40
Mannose phosphate isomerase	PMI	5.3.1.8
Peptidase[1] (1-2)	GL	3.4.11
Peptidase[2]	LGG	3.4.11
Peptidase[3]	PHAP	3.4.11
Peptidase[4]	LT	3.4.11
Phosphoglucomutase	PGM	2.7.5.1
Phosphogluconate dehydrogenase	6PG	1.1.1.43
Phosphoglycerate kinase	PGK	2.7.2.3
Pyruvate kinase	PK	2.7.1.40
Superoxide dismutase	SOD	1.15.1.1
Triosephosphate dehydrogenase (1-4)	TPI	

[1] Resolved using glycyl leucine.
[2] Resolved using leucylglycylglycine.
[3] Resolved using phenylalanyl proline.
[4] Resolved using leucyl tyrosine.

preclude introgression of either rainbow or cutthroat subspecies and confirm, as suggested from the morphometric and meristic data, that these populations are pure Westslope Cutthroat Trout.

The frequency of the *MDH-1* variant in the Job Lake population was calculated as 0.04. A contingency chi square analysis indicates a significant difference between the two populations at this locus ($\chi^2 = 4.89$; $P < 0.05$). This difference also indicates, as suggested from the meristic data, the Picklejar Lake #4 population, and by inference the Picklejar Lake #2 population, have been isolated from the Marvel Lake stock, perhaps since the last ice age.

Previously analyzed Westslope populations have shown much greater intrapopulation variation compared to these two stocks. Loudenslager and Gall (1980) analyzed two populations from Wyoming and Idaho. They found average heterozygosities were 0.035 and 0.045, respectively, and a total of 33% of the loci were polymorphic in at least one population. Allendorf and Phelps (1980) analyzed a wild population of Westslope Cutthroat originating from Hungry Horse Creek, Montana. Average heterozygosity equalled 0.024, and 20% of the loci were polymorphic.

Allendorf and Phelps (1980) also analyzed a hatchery stock (Jocko River Hatchery, Montana), which was derived from the Hungry Horse Creek population. They found a 57% reduction in the proportion of polymorphic loci and a 20% reduction in the average heterozygosity. Average heterozygosity equalled 0.018, and only 9% of the loci were polymorphic. They attributed the loss of variation to both a limited number of founders of the hatchery stock and the effects of genetic drift in the maintenance of the hatchery stock. Allendorf

TABLE 2. Morphometric measures (mm) and meristic counts from Picklejar Lake #4 samples taken in 1984, Picklejar Lake #2 samples taken in 1957, and Marvel Lake sample.

	Picklejar Lake #4				Picklejar Lake #2	Marvel Lake
	Sample size	Mean	Range	95% Confidence limit (2SE)	Mean (n = 17)	Mean (95%) (C.L.)
Measures						
Total length	40	194.8	125.0-366.0	14.8		
Standard length	44	165.7	104.7-312.0	11.9		
Head length	44	36.7	23.6- 78.6	3.0		
Snout length	44	8.7	4.2- 23.4	0.93		
Interorbital width	30	8.8	6.1- 14.2	0.65		
Eye diameter	44	9.0	5.1- 21.3	0.91		
Upper jaw length	44	19.6	11.7- 50.8	1.93		
Counts						
Upper gill rakers	40	6.9	6-8	0.20	19.2*	19.5 (0.6)
Lower gill rakers	41	10.4	9-11	0.20		
Pectoral rays	44	14.4	13-16	0.22		
Dorsal rays	44	12.5	12-13	0.15		
Anal rays	44	11.4	11-12	0.15		
Pyloric caeca	26	30.1	23-38	1.65	30.1	41.2 (4.0)
Scales above lateral line	42	38.9	34-45	0.71	38.7	41.7 (1.0)
Scales along lateral line	42	164.1	152-176	1.79	160.0	145.0 (9.8)
Fish with basibranchial teeth	42	83%		—	100%	

*Total gill raker count.

and Phelps (1980) hypothesize that this loss of variation may correlate with a decreased performance of the stock.

The amount of variation in the Job Lake and Picklejar Lake #4 populations is at a very low level and is even less than that observed in the Jocko River Hatchery. Job Lake stock originated from the Marvel Lake stock. The Marvel Lake stock is similar electrophoretically to the Job Lake stock, and indicates the lack of protein variation originated in Marvel Lake (McAllister et al. 1981). Picklejar Lake #4 is a natural population without a

TABLE 3. Morphological characteristics typical of Westslope Cutthroat Trout, Yellowstone Cutthroat Trout and Rainbow Trout*.

	S. c. lewisi Westslope Cutthroat Trout		*S. c. bouvieri* Yellowstone Cutthroat Trout		*S. gairdnerii** Rainbow Trout	
Character	Typical value	Range	Typical value	Range	Typical value	Range
Pyloric caeca	30-40	24-51	35-45	26-63	50-55	35-75
Gill rakers	18-19	16-24	19-20	17-23	18-20	16-24
Scales in lateral series	165-180	130-205	165-180	128-200	120-140	110-150
Scales above lateral line	—	30-48	—	31-53	28.5	25-32
Basibranchial dentition	—	0-30	—	0-63	absent	
Cutthroat-mark on throat	strong		strong		absent	
Reddish lateral band	weak or absent		weak or absent		strong	

*This table is reprinted from McAllister et al. (1981) and was compiled from the following sources: Behnke (1979), Gold (1977), Roscoe (1974), and Schreck and Behnke (1971).

***Salmo gairdneri* does not include fine-scaled inland forms such as *S. g. kamloops*.

history of plantings or other manipulations. This lack of variation within both populations likely indicates the extreme effects of genetic drift, small founding population sizes or a serious and recent reduction in population size. The Picklejar Lake #4 fish pyloric caeca count, number of gill rakers and number of scales on the lateral line are all at the low end of the Westslope Cutthroat Range and indicate, as does the electrophoretic information, that genetic drift and/or population reduction have probably occurred.

It is important to verify that the lack of variability in the Job Lake population does not result in poor performance compared to other stocks used in Montana or British Columbia. The Picklejar Lakes should be protected as unique and rare examples of Westslope Cutthroat Trout, especially since they are distinct from the Job-Marvel Lake stock, and could be crossed with the Job Lake stock to increase that stock's performance. The population in Picklejar Lake #2 is particularly valuable, and by close genetic association the Picklejar Lake #4 population as well, since the fish spawn on a shoal in Picklejar Lake #2 rather than in an outlet stream. This makes the Picklejar stock ideal for planting in lakes without suitable spawning habitat in tributary streams.

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Notes

Three-Legged Black Bear, *Ursus americanus*, Survives Four Years

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Anderson, Stephen B. 1989. Three-legged Black Bear, *Ursus americanus*, survives four years. Canadian Field-Naturalist 103(1): 85–86.

A yearling male Black Bear (*Ursus americanus*) ear-tagged (number 52) on 27 July 1981 was retrapped on 16 October 1981 and was found to have lost its right hind foot. On 6 November 1985, a hunter shot bear number 52. Thus the bear had survived four years with three feet. Moreover, the bear appeared to be in good condition at the time of its death.

Key Words: Black Bear, *Ursus americanus*, three-legged, survival.

During 1981 and 1982 I trapped and tagged Black Bears (*Ursus americanus*), as part of a home-range study. A yearling male was caught by the right front foot on 27 July 1981, in the Moosehorn Lake area of Kings County, Nova Scotia (44° 58′ N, 64° 27′ W) in an Aldrich foot snare. The bear was immobilized with Ketaset/Rompun, ear-tagged (number 52), and measured before release.

On 16 October 1981 bear number 52 was recaptured, this time near Sheffield Lake, Kings County (44° 48′ N, 64° 25′ W). The bear was immobilized again with Ketaset/Rompun and at this time I observed that the right hind foot was missing above the ankle from what appeared to be a recent amputation. The flesh was still red but not bleeding and no infection was evident. The wound was covered with Anispray® (Rogar/STB), a veterinary antiseptic, and then the bear was fitted with a radio collar and released. Game wardens were informed of the incident, as the injury appeared to be caused by an illegal steel trap.

Several weeks later the collar became stationary. It was located on the ground and I suspected that a hunter had shot the bear and left the collar in the woods.

On 6 November 1985 a call was received from Blair Sheffield saying that he had shot a bear with a tag in its ear (number 52) and a missing right hind foot. The bear was killed near Newtonville, Kings County (45° 01′ N, 64° 22′ W) about 8 km from the original capture site. Cementum annuli of a premolar tooth indicated an age of 5.5 years when killed, making the bear a yearling when it lost its foot. The stump of the amputated foot had calloused over, suggesting that the bear had used it. Field dressed, the bear weighed 143 kg and was in good condition as it had a thick layer of subcutaneous fat.

Upright (1961) reported taking a three-legged bear in New York State. In this case the haunch was completely furred over, indicating that the animal probably did not use the leg. An examination showed that the bone was broken off, probably during its first year. The bear weighed 82 kg hog dressed and was very fat. No age was given.

Potter (1957) reported finding the hind foot of a bear cub in New York State. It appeared to be a fresh cut but no blood was evident. While no trap was found, the bones and ligaments looked as if they were crushed by powerful jaws and teeth. Again, no infection was evident.

Mahoney (1985) reported that in Newfoundland, bears often have serious injury to their forelegs. Mahoney believes these injuries were derived from intense intraspecific interactions.

Trap injury was suspected in this case because of the cleanliness of the amputation and because it was a hind foot, not a fore foot that was injured. However, Mahoney's (1985) suggestion and Potter's (1957) observations indicate that an older bear could have strong enough jaws to break the rear leg bone of a yearling bear during an intraspecific interaction. Adult male bears will attempt to kill younger bears if encountered (Jonkel 1978).

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The Clustered Dock, *Rumex conglomeratus* (Polygonaceae), in Canada

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Morton, J. K. 1989. The Clustered Dock, *Rumex conglomeratus* (Polygonaceae), in Canada. Canadian Field-Naturalist 103(1): 86–88.

The Clustered Dock, *Rumex conglomeratus*, is reported from the London area of Ontario where it is well established. The only other locations in Canada where it is known to occur are in the southern half of Vancouver Island and the neighbouring mainland in British Columbia.

Key Words: *Rumex conglomeratus,* Clustered Dock, Ontario, British Columbia.

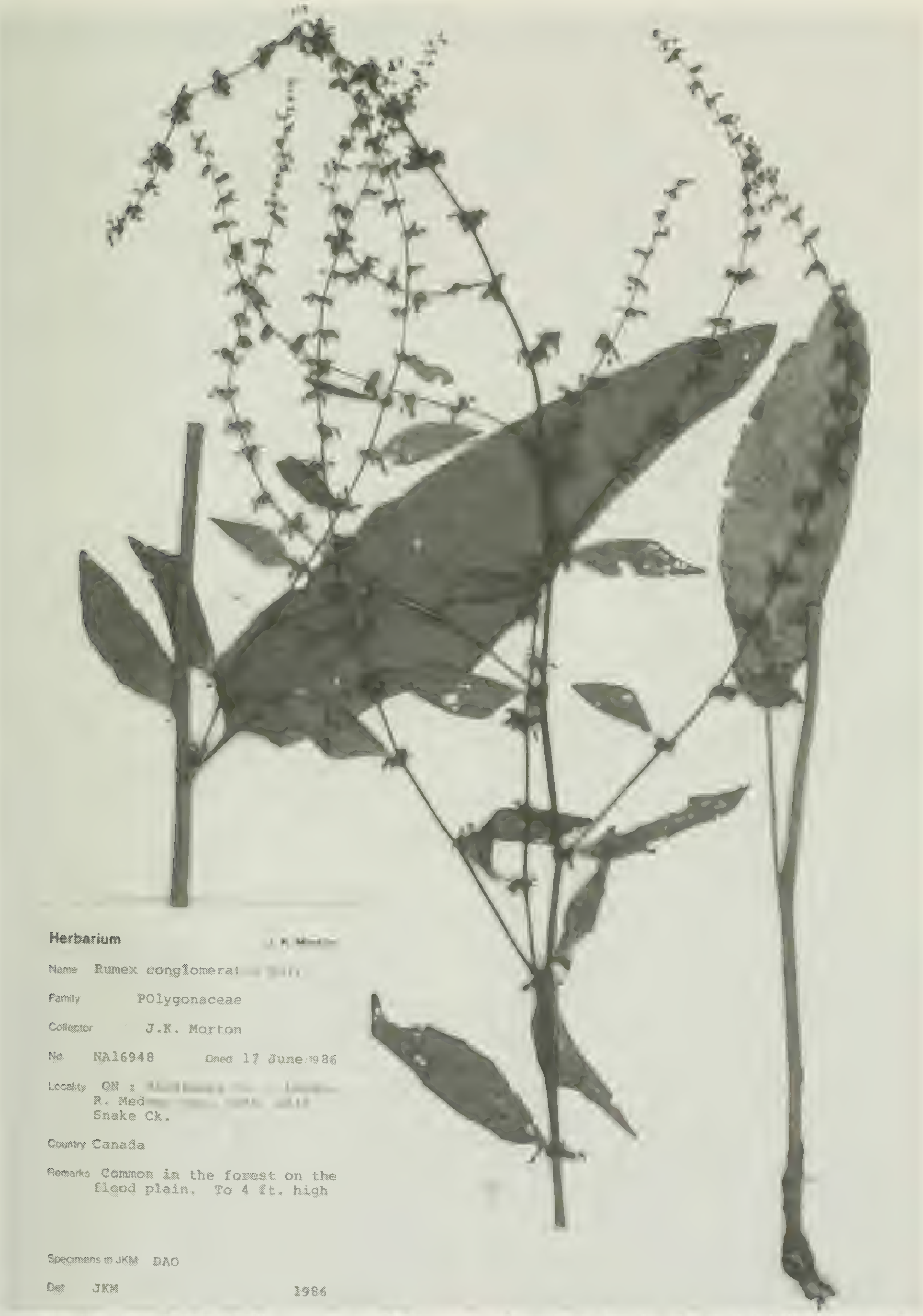
The Clustered Dock, *Rumex conglomeratus* Murr., is a common plant in western Europe where it is often weedy on roadsides, on cultivated and waste land, on river banks, and in open woodland and hedgerows. It has been introduced into North America, but, unlike its close relative, the Curly-leaved Dock, *Rumex crispus* L., it is still of very local occurrence and, in Canada, is only known from restricted areas in Ontario and British Columbia. The discovery of the Clustered Dock in 1986 in open deciduous woodland on the banks of the Medway River in London, Ontario, prompted me to investigate the occurrence of this species in Canada.

In Ontario, the Clustered Dock is well established in the London area on the banks of the Thames River and its tributaries such as the Medway River. The first record from this area appears to be that of Dr. Cavers, who collected a specimen in 1964. Boivin (1966) and Scoggan (1978) report the species as being of doubtful occurrence in southern Ontario on the basis of an immature specimen collected in Guelph in 1941. It has not been confirmed, however, from this area.

The Clustered Dock is also well established in the southern half of Vancouver Island and around the city of Vancouver in British Columbia. Records from this area date back to the beginning of the century, the first collection that I have seen being that of Fletcher collected in Steveston on the outskirts of Vancouver in 1903. Macoun collected it at Nanaimo on Vancouver Island in 1908. Recent collections from these areas indicate that the species still occurs there.

This species also occurs in the United States. Hitchcock et al. (1964) state that it is common on the west side of the Cascades as far south as California. On the eastern side of the continent, Fernald (1970) reports the species to be local in the northeastern United States. It is known to occur in Ohio (Weishaupt 1968), but Voss (1985), Wherry et al. (1979), Seymour (1969) and Mitchell (1986), respectively, do not include it in their floras of Michigan, Pennsylvania, New England and New York. Mitchell (1986) mentions, however, that records of this species from New York are based on immature specimens of *Rumex obtusifolius.*

The Ontario and British Columbia locations provide the only records that I have been able to discover of the Clustered Dock in Canada. Docks are not the sort of plants that attract the attention of most naturalists and field botanists. It is quite possible that this species occurs in other parts of the country, particularly in eastern and central Canada, but has been overlooked.



Herbarium [illegible]

Name Rumex conglomera[illegible]

Family POlygonaceae

Collector J.K. Morton

No NA16948 Dried 17 June/1986

Locality ON : [illegible]
R. Med[illegible]
Snake Ck.

Country Canada

Remarks Common in the forest on the flood plain. To 4 ft. high

Specimens in JKM DAO

Det JKM 1986

FIGURE 1. Photograph of herbarium specimen of *Rumex conglomeratus*, showing characteristic leaf shape and very lax inflorescence.

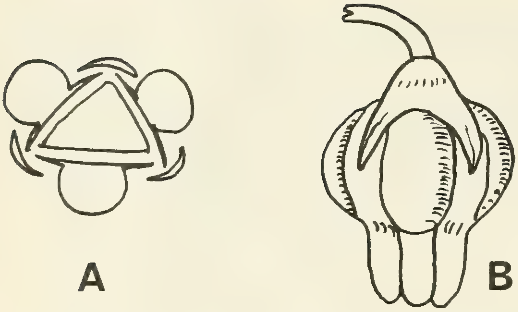


FIGURE 2. Diagram of fruit of *Rumex conglomeratus:* A — cross section showing the three equal-sized tubercles, B — side view.

It is important to collect fruiting material for the identification of docks. Species that may be confused with Clustered Dock are the very common and widespread Curly-leaf Dock (*R. crispus* L.) and the less common Broad-leaved Dock (*R. obtusifolius* L.). This latter is readily recognized by its broader leaves, which have a cordate base, and by its prominently toothed fruiting perianth. The Curly-leaf Dock has a much denser inflorescence and the leaves have noticeably wavy and crispate edges. Its fruits are also much larger (about 5 mm long). The Clustered Dock has narrow leaves which are not crispate or wavy and not cordate at the base. Its inflorescences are lax with widely separate whorls in flower and fruit.

However, immature plants of both the Curly and Broad-leaved docks can have lax, open inflorescences very like that of the Clustered dock and, in addition, the perianths do not take on their characteristic features of size and structure until they are near maturity. The fruiting perianth of the Clustered Dock is small (2 to 3 mm long) with entire segments and three large, equal-sized, swollen tubercles. Another dock, the very rare Red-veined Dock (*R. sanguineus* L.), could more easily be confused with the Clustered Dock but it has only one large tubercle on the fruiting perianth and two much smaller ones. It has been reported from Canada but the reports require confirmation.

Climatic factors may be limiting the spread of the Clustered Dock in North America. In Europe, where this species is native, its distribution does not extend into the colder parts of the continent and is delimited to the north by a line drawn from northern Scotland through the southern tip of Sweden to the Black sea (Tutin et al. 1964; Perring and Walters 1976; and Hultén 1950). This coincides approximately with the -1°C January isotherm. In Canada this species is confined to the two warmest parts of the country — southern British Columbia and southwestern Ontario — areas delimited by the same isotherm.

Voucher material examined:

Ontario: *Cavers* 2 (UWO, DAO) banks of R. Thames, London 12/7/1964.

Morton NA16948 (JKM, DAO) banks of R. Medway opposite Snake Creek, London 17/6/1986.

British Columbia: *Fletcher* 1544½ (DAO) Steveston 28/7/1903.

Macoun 83938 (CAN) Nanaimo 7/7/1908.

Macoun 87954 (CAN) Bearea Lake, Victoria 11/8/1913.

Malte 197684 (CAN) Victoria 18/8/1912.

Groh s.n. (DAO) Steveston 11/10/1930.

Calder & Mackay 31818 (DAO) Courtenay 24/7/1961.

Harrison 76.1 (DAO, CAN) Colquitz Creek, Vancouver Island 1/8/1967.

Acronyms for herbaria are from Holmgren et al. (1981). JKM refers to my herbarium.

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First Confirmed Breeding Record of Le Conte's Sparrow, *Ammodramus leconteii*, in Eastern Ontario

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Villard, Marc-André, and Robert A. Bracken. 1989. First confirmed breeding record of Le Conte's Sparrow, *Ammodramus leconteii*, in eastern Ontario. Canadian Field-Naturalist 103(1): 89–90.

The successful nesting of a pair of Le Conte's Sparrows, *Ammodramus leconteii*, near Hallville, Ontario, was monitored and three young fledged. This is only the fourth record of the species in the Ottawa region and is the first confirmed breeding record in eastern Ontario. The location of the nest in a shallow ditch separating two cultivated fields leads to a brief discussion on habitat selection in this species.

Key Words: Le Conte's Sparrow, *Ammodramus leconteii*, first breeding record, Ottawa, Ontario.

A breeding pair of Le Conte's Sparrows, *Ammodramus leconteii*, was observed at intervals between 7 June and 19 July 1987 near Hallville, Ontario (45° 04′ N, 75° 31′ W), approximately 45 km south of Ottawa. This represents the third known nesting location for the species in southern Ontario. It is the fourth sight record of Le Conte's Sparrow in the Ottawa district, the others being a fall record at Mer Bleue bog (5 September 1971; B. MacTavish, M. McKie, and H. Williamson; Goodwin 1972) and spring records at Richmond (28 May 1977, B. Gorman, I. Jones and P. Jones) and near Metcalfe (19 May 1974; R. A. Foxall and R. Poulin; Goodwin 1974). In the latter case, breeding was suspected but no monitoring of the two birds was conducted (R. Poulin, National Museum of Natural Sciences, personal communication). Metcalfe is located 20 km north of our site.

The Hallville area is moderately cultivated, with scattered woodlots. The birds were closely associated with the vegetation of a vernally inundated ditch separating two cultivated fields. The ditch was approximately 135 m long, 2.5 m wide and 1 m deep. The nest was almost certainly located in this ditch, as both male and female were regularly observed along it, and young were later found there. However, no search for the nest was undertaken so as to avoid additional stress to the birds.

The male was first observed by M.-A. Villard at 0700 h on 7 June in an Alfalfa (*Medicago sativa*) field on the south side of the ditch. The bird appeared strongly territorial, singing with regularity and hovering shortly, giving alarm notes, upon the observer's approach. In the evening of the following day, when we returned to the site, the bird was singing irregularly. There was no sign of a female. On 10 June, the male was photographed and his song recorded. Upon learning that the field was due to be mowed that evening, we consulted the landowner, who kindly agreed to leave the corner to which the sparrow seemed to return regularly, uncut.

On 18 June, the bird was found along the ditch, far from the uncut corner, but it was still reacting strongly to our presence, constantly emitting alarm calls. A second individual, presumably a female, was first detected the next day, as it flushed from the dense vegetation bordering the ditch. The birds were frequently found around a clump of Reed Canary Grass (*Phalaris arundinacea*). The other dominant plant species along the ditch were Tufted Vetch (*Vicia cracca*), Canada Blue Grass (*Poa compressa*), Awnless Brome Grass (*Bromus inermis*), Pussy and Slender willows (*Salix discolor* and *S. petiolaris*, respectively) and Blackish Bulrush (*Scirpus atrovirens*).

Breeding was confirmed on 14 July, when one fledged young was seen. Subsequent observations (on 19 July) revealed that at least three young fledged. They were behaving like the female, remaining in the dense vegetation until we flushed them and then going back to safety a short distance away.

There are only a handful of breeding occurrences in southern Ontario. The summer records closest to Ottawa are from Holland River marshes, north of Toronto, in 1937-48 (Speirs 1985). More recently, a fledged young was found by C. Campbell near Luther Marsh, north of Waterloo. This was the only confirmed nesting record obtained in southern Ontario in five years of fieldwork for the *Atlas of the Breeding Birds of Ontario* (Sandilands and Campbell 1987). Thus, our sighting extends the area in which breeding is known for this species, although it is less isolated than the breeding record of Saint-Fulgence, Québec (Boulva and Browne 1964). Godfrey (1968) suggested that the latter record could indicate a more or less continuous breeding distribution between the Abitibi and Saguenay regions.

Another important issue raised by our record pertains to habitat selection. Le Conte's Sparrow is known to breed in a variety of moist and open habitats, such as grassy marshes, meadows, bogs, and the damp sections of cultivated hayfields (Salt and Salt 1976). It should thus be negatively affected by the drainage of fields for cultivation. Although habitat destruction may account for the apparent rarity of the species in southern Ontario (Sandilands and Campbell 1987), our record indicates that it can adapt to some extent to the new microhabitats created by agricultural practices. However, it is still unclear to us whether the sparse occurrence of the species in the eastern part of its range is actual or simply an artefact of its discreet "mouselike" behaviour, as suggested by various authors (Ouellet 1965; Godfrey 1968; Sandilands and Campbell 1987).

Areas similar to the Hallville site could probably be found throughout eastern Ontario. Exhaustive surveys of such sites would thus be required to determine the actual status of this enigmatic species.

Acknowledgments

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Right Whale, *Eubalaena glacialis*, Sightings in Waters off Newfoundland and Labrador and the Gulf of St. Lawrence, 1978–1987

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Lien, Jon, R. Sears, G. B. Stenson, Peter W. Jones, and I-Hsun Ni. 1989. Right Whale, *Eubalaena glacialis*, sightings in waters off Newfoundland and Labrador and the Gulf of St. Lawrence, 1978–1987. Canadian Field-Naturalist 103(1): 91–93.

Five sightings of Right Whales (*Eubalaena glacialis*) made in Newfoundland and Labrador and the Gulf of St. Lawrence between 1978 and 1987 are reported. Most were seen in between July to October, but one was sighted in February. Sighting rates of Right Whales in these waters, compared to other species of cetaceans, indicate they are exceptionally rare.

Key Words: Right Whale, *Eubalaena glacialis*, cetacean, Newfoundland, Labrador, Gulf of St. Lawrence.

The Right Whale (*Eublaena glacialis*) is an endangered Balaenopterid rarely seen in eastern Canadian waters outside of the Bay of Fundy (Gaskin 1982, 1987; Hay 1985). Kraus et al. (1985) suggest that the Western North Atlantic population of Right Whales is a single stock, which moves seasonally from waters off Nova Scotia in summer to southeastern United States coasts in winter.

Mitchell (1975) estimated a Northwest Atlantic population in the low hundreds. Price (1987), using a mark-recapture technique based on photographic identification of individuals, has estimated from 97 to 301 animals in this population. Gaskin (1987) estimates 150 to 380 ± 688 individuals. Photographic identifications of about 250 individuals have been made in the past five years and entered in the Western North Atlantic Right Whale catalogue (J. Prescott, New England Aquarium, personal communication).

The purpose of this paper is to describe the temporal and geographic distribution of Right Whales in waters off Newfoundland and Labrador and the Gulf of St. Lawrence based on sightings of the whale made during the past decade (1978–1987).

Methods

Sightings of Right Whales were made during sighting programs operated at Memorial University of Newfoundland (MUN), Fisheries and Oceans — Newfoundland Region (DFO) and the Mingan Island Cetacean Study (MICS), in which all cetaceans encountered were noted.

MUN maintains an extensive sighting network composed of Canadian Coast Guard lighthouse-keepers, students and faculty, and of volunteer whale watchers. This sighting network, organized since 1979, is comprehensively described in Lynch (1987). A total of 65 700 nautical miles were observed from ships and 3435 person-weeks of observation from shore were completed from 1979 to 1987.

DFO periodically received sighting reports from research cruises by their vessels between 1978 and 1987. MICS routinely surveys the North Shore of the Gulf of St. Lawrence from late July to October each year.

In all of the sighting programs, most effort was expended during months from May to October and winter effort was substantially reduced or non-existent. Effort was greater in eastern regions of insular Newfoundland than in other areas.

Results

Only five sightings of Right Whales occurred in waters off Newfoundland and Labrador and the Gulf of St. Lawrence from 1978 to 1987. Reports are presented in Table 1 and their locations are shown in Figure 1. Most sightings were made in summer or early fall off Newfoundland's east coast or near the North Shore of the Gulf of St. Lawrence. One sighting occurred in February on the southwest coast of Newfoundland. The 1978 observation of the Right Whale in Trinity Bay reported frequent feeding activity. Other Right Whales sighted did not appear to be feeding but

TABLE 1. Right Whale (*Eubalaena glacialis*) sightings in Newfoundland and Labrador waters (1978–1987).

Date(s)	Seen By	Latitude/Longitude	Location
10–21 July 1978	MUN[1]	47°05′N; 53°49′W	Norman's Cove, Trinity Bay
25 August 1979	DFO[2]	47°00′N; 53°45′W	St. Mary's Bay
6 October 1981	MICS[3]	50°11′N; 65°06′W	Sheldrake, North Shore, Quebec
17 February 1984	MUN	47°33′N; 59°10′W	Channel Head, Port aux Basques
26–28 July 1984	MUN	46°45′N; 53°38′W	Peter's River, Holyrood Bay

[1] Memorial University of Newfoundland.
[2] Canadian Department of Fisheries and Oceans.
[3] Mingan Island Cetacean Study.

were simply seen traveling without exhibiting other distinctive behaviours.

The animal seen in July 1984 was entrapped in a codtrap and resisted all attempts by humans to come near it. At times it was very aggressive toward approaching boats. Eventually the animal towed the codtrap with all its supporting grapnels out to sea. Despite extensive searching the animal was not seen again, and it is believed that it could not have survived.

Discussion

The only sighting program in this study where results can be quantified was the one operated by MUN. For this program, sighting rate of Right Whales by land-based observers was 0.0009 per person-week of observation. This compares with 0.02 for Killer Whales (*Orcinus orca*); 0.34 for Humpbacks (*Megaptera novaeangliae*); 0.22 for Minke Whales (*Balaenoptera acutorostrata*); and 0.32 for Long-finned Pilot Whales (*Globicephala melaena*) [Lynch 1987]. Although Right Whales occasionally occur in waters off Newfoundland and Labrador, they are indeed very rare.

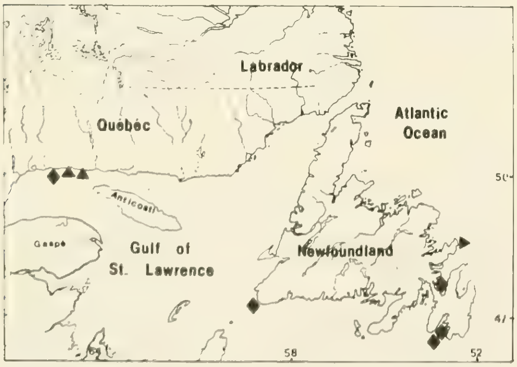

FIGURE 1. Locations of Right Whale (*Eubalaena glacialis*) sightings (1978–1987). Sightings reported here are represented by ◆; sightings cited from Sears (1980) and Beamish (1981) are represented by ▲.

During the decade (1978-1987), there were three additional sightings of Right Whales that have been reported. Sears (1980) saw three to four Right Whales on 13 to 16 September 1976 in Moisie Bay, Quebec (50°18′N; 65°57′W). Another animal was seen in the same season the following year in the same location (R. Greendale, MICS, personal communication). Beamish (1981) saw a single Right Whale on 31 August 1981 near Newman's Cove, Bonavista Bay, Newfoundland (48°37′N; 53°45′W).

It is difficult to discern a pattern in the few sightings presented here. Right Whales are believed to exhibit seasonal north–south migrations with summer distribution in the north and wintering occurring in the south (Reeves et al. 1978; Hay 1985; Gaskin 1987). Dates of sightings reported here as well as those reported by Sears (1980), Greendale, and Beamish (1981) conform to this seasonal pattern. The exception is the single animal seen in February at Port aux Basques, Newfoundland. Hay (1985) noted that some Right Whales may over-winter in the New England area. Mayo and Hamilton (1987) have substantiated this supposition. The sightings presented here indicate that, at least on occasion, they may also over-winter in Gulf of St. Lawrence waters.

The sightings reported here did not include photographic identification of the individual whales (Payne et al. 1983). This is perhaps due to the rarity of observations of Right Whales in these waters. Such photographic records are critical to determine whether animals sighted in Newfoundland and Labrador and the Gulf of St. Lawrence and those in other areas such as the Bay of Fundy and Cape Cod include the same individuals and thus constitute a single stock.

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Range Extension for the Coeur d'Alene Salamander, *Plethodon vandykei idahoensis*, to the Canada–United States Border

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Wilson, Albert G., Jr., Evelyn M. Simon, and John H. Larsen, Jr. 1989. Range extension for the Coeur d'Alene Salamander, *Plethodon vandykei idahoensis*, to the Canada–United States border. Canadian Field-Naturalist 103(1): 93–94.

This report documents a 40-km north–northwest range extension for the Coeur d'Alene Salamander (*Plethodon vandykei idahoensis*). Its close (3.2 km) proximity to the Canada–United States boundary suggests this subspecies occurs naturally in British Columbia.

Key Words: Coeur d'Alene Salamander, *Plethodon vandykei idahoensis*, Idaho, British Columbia.

On 20 September 1986, a Coeur d'Alene Salamander (*Plethodon vandykei idahoensis*) was collected by A. G. Wilson from the base of Copper Falls in the Purcell Mountains of Boundary County, Idaho (48°58′N; 116°09′W). The 5.3-cm (snout-vent length) female was discovered at 1030 m elevation beneath a flat rock in the waterfall's spray zone. Substrate temperature was 6.9°C and local air temperature was 7.8°C. The coloration and markings of the animal were similar to those depicted by Stebbins (1985). The specimen was preserved and deposited in the Conner Museum of Washington State University, Pullman (C.M. 87-265).

This is the first record of the Coeur d'Alene Salamander in Boundary County. The nearest known population resides 40 km to the south-southeast along the Yaak River in Lincoln County, Montana [A. G. Wilson, Jr., and E. M. Simon. 1987. Status of the Coeur d'Alene Salamander (*Plethodon vandykei idahoensis*) in Montana. Report submitted to to Montana Natural Heritage Program, Helena, Montana.].

Copper Falls is only 3.2 km south of the Canada–United States boundary and is part of the Moyie River drainage that extends into southeastern British Columbia. This drainage would seem a likely northward dispersal route for the Coeur d'Alene Salamander in suitably damp situations (*see* Nussbaum et al. 1983 for comments on microhabitats). Although not mapped in British Columbia in recent guides (Cook 1984; Green and Campbell 1984; Stebbins 1985) it was incidently included (as *Plethodon vandykei* without mention that this was a new Canadian record) in a list of vertebrates found in 1981-1983 in the Kuskonook Mine (49 21′N, 116 44′W), B.C., by Holmberg, Angerilli and LaCase (1984). Our report, by significantly shrinking the distributional gap between this site and previous northern records, supports a conclusion that its occurrence in British Columbia is natural. This raises the number of known Canadian *Plethodon* species to three: *P. cinereus*, the Eastern Redback Salamander, from Ontario to Prince Edward Island and *P. vehiculum*, the Western Redback Salamander, and *P. vandykei idahoensis* from southwestern and southeastern British Columbia, respectively.

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Common Loons, *Gavia immer*, Nesting in Deadwater Streams

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Strong, Paul I. V., and John A. Bissonette. 1989. Common Loons, *Gavia immer*, nesting in deadwater streams. Canadian Field-Naturalist 103(1): 94–96.

Common Loons (*Gavia immer*) were found nesting 10 to 800 m from the main bodies of lakes in shallow, deadwater streams. In breeding territories without islands, deadwater streams were strongly favored for nesting over other mainland sites. Nesting success in deadwater streams was greater than on islands or at mainland sites.

Key Words: Common Loons, *Gavia immer*, nesting, deadwater streams.

Common Loons (*Gavia immer*) nest on lakes of all sizes in the northernmost tier of conterminous United States and in Alaska, Canada, Greenland, and Iceland (American Ornithologists' Union 1983). On individual lakes, loons nest in a variety of locations [e.g. marshes, islands, mainland] (Vermeer 1973; McIntyre 1975; Sutcliffe 1980; Alvo 1981). Islands are favored as nesting locations when available (McIntyre 1975; Smith 1981) and often confer greater reproductive success than nests in other habitats (McIntyre 1975; Sutcliffe 1980; Titus and Van Druff 1981).

To date, no studies of Common Loons have reported the use of slow-moving inlet or outlet streams for nesting. In this paper, we describe the use of deadwater streams for nesting and document the use, availability, and nesting success of these and other potential nest habitats for Common Loons.

Study Area and Methods

We were studying habitat selection by Common Loons on large, remote lakes in north-central Maine (approximately 46° N, 69° W). From 1982 to 1984 we collected data on nest location and success on seven lakes ranging in size from 200 to 1000 ha. Additional data for 1979 and 1980 were available for three of the lakes (Christenson 1981). Individual lakes had two to eight breeding pairs of loons.

We located nests by searching all shoreline areas and islands from ice-off (usually early May) to mid-July. After a nest was located, we discontinued shoreline searches in that area and periodically checked the status of the nest from a distance until hatching or abandonment.

Results

We found 69 loon nests in 25 different breeding territories. Previously used nest bowls or nearby areas were often used in subsequent years (Strong et al. 1987), resulting in only 40 discrete nest locations.

Eighteen (45%) nests were on islands. Eleven of the 22 mainland nests were in slow-moving inlet or outlet streams commonly called backwaters or deadwaters in this area.

The deadwater streams used by the loons for nesting were shallow (<1 m) and narrow (5 to 10 m wide). Ericaceous shrubs typical of boggy areas were dominant plant types. Stream current was slow or absent and water levels fluctuated only with fluctuations on the lake.

Loons constructed nests at various distances from the mouths of the streams. One nest was located approximately 10 m upstream from the mouth and was visible from the main body of the lake. All others were obscured from the main body of the lake by bends in the streams. We estimated the distances from the nests to the stream mouths for nests >50 m upstream and rounded the distances off to the nearest 50 m. The nests were 10, 100, 150, 200, 200, 350, 400, 400, 500, 500, and 800 m from the stream mouths.

Loons seemed to prefer nesting in deadwater streams or on islands. In six breeding territories (boundaries determined after intensive observations of resident pairs (Strong 1985)) with deadwater streams but no islands, seven of eight nest sites were in the streams. In ten territories with at least one island but no streams, 11 of 12 nests were on islands. Seven territories had islands and deadwater streams. Seven nests were on islands, four were in streams, and three were at other mainland sites. Two territories had no deadwater or island nesting habitat.

Stream-nesting loons enjoyed greater nesting success (at least one hatched egg) than loons that nested on islands or at mainland sites. Fourteen (82%) of 19 stream nests were successful; 16 (52%) of 31 island nests were successful; and seven (37%) of 19 mainland nests were successful.

Discussion

Factors affecting the selection and success of Common Loons nests have been discussed (Olson and Marshall 1952; Vermeer 1973; McIntyre 1975; Sutcliffe 1980; Yonge 1981). Nesting on islands is thought to be a response to mammalian predation on eggs (McIntyre 1975; Sutcliffe 1980).

On our study area, the high degree of nesting success in deadwater streams suggests that they were at least as good for nesting as islands. We were unable to determine the ultimate cause of nest failure for most nests, so we have no conclusive evidence for the fact that nesting success was greatest in the deadwater streams.

We suspect that the greater nesting success may have been the result of greater nest attentiveness. Each of the study lakes had two to eight territorial pairs of loons. One to five resident loons without territories were also present throughout the summer. Additionally, non-resident loons were often present on the lakes for varying periods of time. It was not unusual to see a group of 3 to 10 loons anywhere on the lakes during any part of the breeding season. However, only nesting birds were seen in the deadwater streams.

During incubation one member of a nesting pair often joined these small groups when they entered the breeding territory. Several times we observed both members of a nesting pair interacting with the groups. At these times, the nest would be left uncovered up to one hour.

We believe that the activities of these small groups may be a negative influence on nesting success. However, for loons nesting several hundred meters upstream away from the main body of the lake, these activities are not visible and the stimulus to leave the nest may be reduced. In effect, the location of the nest may isolate the incubating bird from potentially distracting activities on the main body of the lake. This may be especially important when there are multiple breeding pairs on the lake or when the lake is visited regularly by non-resident loons. Nesting in deadwater streams may be important on lakes with heavy boat traffic. Loons seem to select nesting areas with low probabilities of human disturbance on some lakes (Sutcliffe 1980; Alvo 1981).

Acknowledgments

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Additions to the Lichen Flora of Alberta, Saskatchewan, and Manitoba

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Johnson, J. D. 1989. Additions to the lichen flora of Alberta, Saskatchewan, and Manitoba. Canadian Field-Naturalist 103(1): 96–99.

An ecological survey in the forested regions of Alberta, Saskatchewan, and Manitoba adds four species to the known lichen flora of Alberta, three species to the flora of Manitoba, and provides additional information on a recent new record from Saskatchewan.

Key Words: Alberta, Saskatchewan, Manitoba, lichens, new records.

During an ecological survey in the forested regions of Alberta, Saskatchewan and Manitoba, several interesting lichen collections were made. After consulting standard references (Bird 1972; Hale 1979; Thomson 1984) and surveying a number of herbaria (ALTA, CAFB, CANL, MMMN, SASK, UAC, WIN, and WIS) [acronyms follow Holmgren and Keuken (1974)], several of these collections were determined to be first records for these provinces. This note adds four species to the known lichen flora of Alberta, three species to the known flora of Manitoba, and provides additional information on a recent new record from Saskatchewan (Thomson 1987).

Numbers in brackets in the following listing are voucher numbers. All collections are those of the author, except as noted. Voucher specimens are deposited in the herbarium of the Northern Forestry Centre in Edmonton (CAFB). Collection localities are indicated in Figure 1. Nomenclature follows Egan (1987).

Bryoria subdivergens (Dahl) Brodo & D. Hawksw. Alberta: Sugarloaf Fire Lookout Road, 34 km N of Coleman; 49° 57′ N, 114° 32′ W; Alpine Larch (*Larix lyallii*)–Grouseberry (*Vaccinium scoparium*) stand (76219). In their revision of *Alectoria* and its allied genera, Brodo and Hawksworth (1977) noted that North American material named as *Alectoria subdivergens* was misidentified and concluded that *Bryoria subdivergens* was still only known from the type locality in southwest Greenland. In a later paper, however, Brodo and Alstrup (1981) expanded the description of the species and re-evaluated its distribution, indicating seven new localities in southwestern Greenland and a record from an alpine community in the Bitterroot Mountains of Montana. The present collection comes from the top of a gently sloping, northeast-facing rock outcrop in an open stand of Alpine Larch and Grouseberry at an elevation of 2290 m. Much of the rock is covered with moss. There is also considerable larch needle litter covering the rock. The lichen is found on a few bare spots on the rock and it is not common. This collection represents the second reported record for North America.

Catapyrenium cinereum (Pers.) Korb. Saskatchewan: Highway 167, N of Meridian Creek; 54° 32′ N, 102° 07′ W; limestone outcrop (7593). This species was recently discussed in a paper by Thomson (1987). The Saskatchewan locality noted on his distribution map is based on the above specimen. The lichen was found growing over two species of moss, *Encalypta rhaptocarpa* and *Myurella julacea*, on top of a limestone outcrop near Amisk Lake at an elevation of 303 m. The patch of lichen was approximately 3 cm in diameter. This species normally grows on soil or humus, especially in calcareous habitats. It is curcumpolar, arctic-alpine, and boreal, and ranges into New England, the north-central states, and California (Thomson 1984). The Saskatchewan collection locality is more or less in the middle of a patchy North American distribution for the

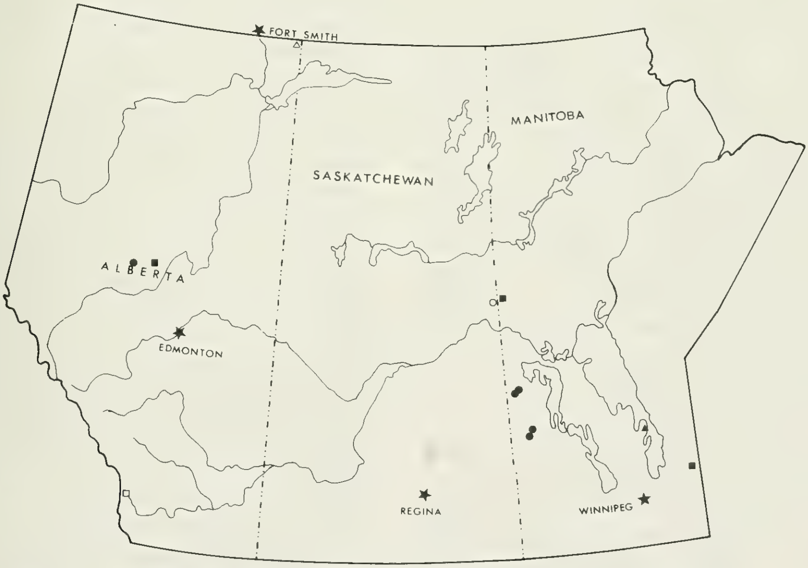

Figure 1. Collection localities for *Bryoria subdivergens* (□), *Catapyrenium cinereum* (○), *Cetraria laevigata* (△), *Collema subflaccidum* (▲), *Heterodermia speciosa* (■), and *Pseudevernia consocians* (●).

species. The nearest known locality to the Saskatchewan site is at Churchill, Manitoba (Thomson 1987).

Cetraria laevigata Rass. Alberta: E shore of Andrew Lake; 59° 52′ N, 110° 06′ W; Jack Pine (*Pinus banksiana*) – lichen stand (72504). This is an arctic-alpine and boreal tundra species with an extensive amphi-Beringian distribution. In North America it is found from Alaska eastward across northern Canada and southward in the high mountains of New England (Karnefelt 1979). Its primary habitat is the dense plant cover of the tundra associated with ericaceous shrubs and lichens such as *Cetraria cucullata* and *Cladonia* spp. Secondary habitats include open places in the subarctic, wet tundra, and rarely wood (Karnefelt 1979). It prefers slightly moister habitats than *Cetraria islandica*. It can be distinguished from the latter by less regular branching and by its marginal pseudocyphellae, which form a distinct, continuous line that is usually distinct in upper parts of lobes and sometimes forms a somewhat broken line in lower parts. The marginal pseudocyphellae on *C. islandica* only occasionally form a continuous line, and then only on the upper parts of the lobes (Karnefelt 1979). The occurrence of the species in extreme northern Alberta extends the continental range by a few degrees south from the nearest Northwest Territories localities indicated by Thomson (1984).

Collema subflaccidum Degel. Manitoba: Provincial Road 234, Gladstone Heights, Lake Winnipeg; 51° 53′ N, 96° 44′ W; limestone rock outcrop (6159). This is a species usually found on bark at the base of trees, seldom on rock (Degelius 1974). It is common in open forests and along roadsides in eastern North America from Ontario south to the Gulf of Mexico (Hale 1979). Western North American localities include Arizona, Wyoming, coastal British Columbia (Degelius 1974), and Jasper National Park in Alberta (collection in CANL). The Manitoba collection comes from an area northwest of the main focus of the species' distribution.

Heterodermia speciosa (Wulf.) Trev. Alberta: "near Otauwau Cabin", Slave Lake Forest Reserve; on spruce (A. H. Brinkman 4193). Manitoba: Provincial Road 314, 2 km S of Cat Lake, 50° 35′ N, 95° 25′ W; granite rock outcrop (6160). Mistik Creek, NW of Cranberry Portage; 54° 39′ N, 101° 30′ W; granite rock outcrop (5077). This species is common on deciduous trees and mossy rocks in mature woods and swamps. Its primary distribution is somewhat similar to the preceding species but does not extend quite as far north or south (Hale 1979). The Brinkman (1931) report (as *Anaptychia speciosa*) of this species from Alberta was discounted by Bird (1972) on the basis of Hale and Culberson's (1970) claim that North American records of this species were based on misidentifications. However, Egan (1987) accepts it as a valid species for North America, and a specimen of the Brinkman collection cited above and deposited in CAFB was verified by John Thomson as *Heterodermia speciosa*. The Manitoba collections of this species, from typical substrates, extend the distribution northwestward from that indicated in Hale (1979). The Alberta collection represents one of several outliers of the species' main range. Others include collections from southeast of Great Slave Lake (Thomson et al. 1969) and Colorado in WIS, and two collections from the Mackenzie valley (Bird et al. 1980) in UAC. The occurrence of the Alberta specimen on (black) spruce is noteworthy.

Pseudevernia consocians (Vain.) Hale & Culb. Alberta: Goose Mountain Fire Tower Road, 10 km NW of Swan Hills; 54° 46′ N, 115° 32′ W; string fen (4591). Manitoba: Provincial Road 357, 1 km W of Beautiful Lake, Duck Mountain Provincial Park; 51° 33′ N, 101° 01′ W; wooded bog (6179). Provincial Road 366, NE of Moosehorn Lake, Duck Mountain Provincial Park; 51° 51′ N, 100° 56′ W; treed fen (6180). 6.5 km E of Harte Mountain, Porcupine Provincial Forest; 52° 28′ N, 101° 20′ W; wooded bog (6177). Provincial Road 365, 1.5 km E of Bell Lake, Porcupine Provincial Forest; 52° 31′ N, 101° 12′ W; wooded bog (6178). All collections of this species came from Black Spruce (*Picea mariana*). At the Bell Lake site this species was particularly abundant on the lower branches of the spruce. It was rare at the Alberta site. All specimens were densely isidiate, but no apothecia could be found. Hale (1979) states that this species is common on conifers in mountainous areas in eastern North America. The preference for higher elevations is evident in the locations of the cited specimens. The Manitoba collections come from the areas of highest elevation in that province, and the Swan Hills in Alberta represent some of the highest elevations in the province outside of the mountains. The main distribution of the species is from west of Lake Superior in Ontario, east across southern Canada to the Atlantic, and south in the eastern United States to Georgia and Alabama (Hale 1979). The occurrence of this species in

Manitoba, and particularly Alberta, extends the distribution well to the northwest of that indicated by Hale (1979).

Acknowledgments

I would like to thank I. M. Brodo for determination of the *Bryoria* and *Catapyrenium* specimens and J. W. Thomson for determination or verification of all other specimens. I would also like to thank the curators of the various herbaria for providing specimens or distribution information.

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News and Comment

Publication Schedule

An apology is made to readers and authors for the inordinate delay in the appearance of this issue, 103(1). Future publication delays should be progressively reduced.

FRANCIS R. COOK
Editor

Notice of The Ottawa Field–Naturalists' Club 111th Annual Business Meeting 9 January 1990

The 111th Annual Business Meeting of the Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building. Metcalfe and MacLeod streets, Ottawa on Tuesday, 9 January 1990 at 2000 h.

ROY JOHN
Recording Secretary

Call for Nominations for the 1990 Council of The Ottawa Field–Naturalists' Club

A nominating committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1990, as required by the Constitution.

We would like to remind Club members that they also may nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field–Naturalists' Club no later than 1 December 1989.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 1 December 1989. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

BILL GUMMER
Chairman, Nominating Committee

The Ottawa Field–Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5

Call for Nominations for the 1989 Ottawa Field–Naturalists' Club Awards

Nominations are requested from Club members for the following awards:

Honorary Membership
Member of the Year Award
Service Award
Conservation Award
Anne Hanes Natural History Award

Description of these awards is given in *The Canadian Field–Naturalist* 96(3): 367(1982).

With the exception of honorary members all nominees must be members in good standing.

Nominations and supporting rationale should be submitted no later than 15 December 1989 to

BILL GUMMER
Chairman, Awards Committee

The Ottawa Field–Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5

1989 Baillie Fund Grants — Call for Applications for 1990

The trustees of the James L. Baillie Memorial Fund for Bird Research and Preservation were pleased to support three non-atlas projects in 1989, as well as providing seven atlas travel grants to volunteers in the Alberta and Maritimes breeding bird atlas projects. In total, $5,841.50 were granted to the recipients. Grants were provided to David Lemon for continuing banding studies of a sedentary population of Dark-eyed Juncos in Newfoundland, the Ottawa Banding Group for banding studies of North American migrants on Andros Island in the Bahamas and the Ontario Nest Records scheme.

Application are welcome for funding in 1990. All projects must be conducted in Canada, and preference will be given to projects conducted by amateurs or by professionals who use large amounts of data collected by volunteers. Thesis projects will be considered but are less likely to receive support than projects of similar quality by persons with less access to other funding sources.

All applications must be submitted on forms available from the Secretary. Non-atlas project grant requests and supporting letters of recommendation should be postmarked by 31 December 1989 to be guaranteed consideration by the Trustees. Atlas travel grant requests must be received by 1 March 1990, and should be competed only after consultation with the coordinator of the appropriate atlas.

The current board of Trustees consists of Fred Bodsworth (Past Chairman), Robert Curry, David J. T. Hussell (Chairman), Ross D. James, Alex. L. A. Middleton, Erica Nol, Ronald Tasker and Linda M. Weseloh. The chief source of funding is the Jim Baillie Birdathon conducted annually by the Long Point Bird Observatory, but direct donations are welcome and tax deductible in Canada. A receipt will be issued. Application forms, instructions and further information can be obtained from Michael S. W. Bradstreet, Secretary, c/o Long Point Bird Observatory, Box 160, Port Rowan, Ontario N0E 1M0. The address for donations is the same.

MARTIN K. MCNICHOLL
former secretary

Second Annual Conference: The Society for Ecological Restoration

The Society for Ecological Restoration announces its second annual conference, to be held in Chicago, Illinois, 29 April-3 May 1990 at the Sheraton International Hotel at O'Hare.

The program will include special sessions on Prairie Restoration, Restoration and Global Climate Change, Setting Standards for Monitoring Restoration Projects, Restoration and Recovery of Endangered Species, and Restoration Philosophy. As well, field trips are planned to include the famous prairie restoration project at Fermi National Laboratory, the Des Plaines River and wetland restoration project, Indiana Dunes National Lakeshore projects, Chicago's urban prairies, and University of Wisconsin Arboretum and Society offices in Madison.

The special sessions will explore the state of the art as it applies to key environmental issues and a full program of contributed papers and posters, special lectures, workshops, the field trips and other special events are designed to facilitate communication among and between restorationists, decision makers and the general public. The deadline for submission of abstracts for contributed papers is 15 January 1990.

WILLIAM R. JORDAN, III

Society for Ecological Resoration and Management, The University of Wisconsin Arboretum, 1207 Seminole Highway, Madison, Wisconsin 53711.

Book Reviews

ZOOLOGY

Audubon Wildlife Report

By The National Audubon Society, edited by R. L. Di Sylvestro. 1987. Academic Press (Canadian distributor, Harcourt Brace Jovanovich, Don Mills, Ontario). 697 pp., illus. U.S. $39.95; $59.25 in Canada.

This book is the third volume of the Audubon Wildlife Report Series (both previous volumes are also still available). The purposes of these publications are to summarize significant events in American conservation from the preceding year, report on a different national resource agency each year, to provide species accounts primarily of selected rare or endangered species, and to publish names and telephone numbers of people and organizations involved in conservation issues. The book contains an extremely impressive amount of information on the current conservation affairs in the United States.

Opinions are not expressed, rather the debates are examined from opposing viewpoints in a factual manner. Names of individuals and groups involved and their roles in an issue are given, as are dollar values attached to the various projects. For example, the U.S. Endangered Species Act has not been reauthorized by Congress and was not voted on in Senate for the second year. Senators Bentsen (Democrat: Texas) and Heflin (Democrat: Alabama) placed holds on the bill based on their concerns that the Act would preclude industrial developments in their states, owing to probable effects of those developments on listed endangered species.

Two other examples are particularly relevant to Canada. The first involves proposed developments on the Platte River and its tributaries. The Platte River is of critical importance to about 80% of the North American Sandhill Crane (*Grus canadensis*), population, as well as to Whooping Cranes (*G. americana*), as a migration stopover area. Wildlife habitat along the river has already been substantially reduced and the proposed projects would leave few remnants. A second is the disposition of the Arctic National Wildlife Refuge, which is habitat and the calving area of the Porcupine Caribou (*Rangifer tarandus*) herd. The U.S. Interior Department has recommended opening the entire north slope to oil and gas leasing.

Other chapters review the various federal fisheries and wildlife programs including the endangered species program, the National Wildlife Refuge system, and conservation efforts of the National Forest Service. Several current and controversial issues are examined including animal damage control, leg-hold trapping, predator control, and international problems in wildlife conservation.

The issue of cumulative environmental impacts of development projects has become a major concern within the American conservation movement. That is, viewed in isolation, a particular project may reduce only local populations of wildlife species, yet when placed in context with many other similar projects the total effect is substantial. Canadian environmental impact statements have also tended to view projects in a parochial manner as well.

The featured department in this volume is the Bureau of Land Management. That agency is responsible for managing 270 million acres of public lands, primarily in western states and Alaska. A disburbing statement (p. 273) says the Bureau feels that it has no legal requirement to protect Spotted Owls (*Strix occidentalis*) on the lands which it administers. The Bureau currently is involved in an inter-agency program to protect the owls, but has insisted on primacy of the timber resource and will protect only 300 acres of old-growth per pair of owls, for 90 pairs. The workings of the Bureau and its conservation record are well documented in this book.

Species accounts are provided for seven mammals, three birds, two fish, one insect, and two plant species. Each chapter relates present knowledge, status, management and protection measures, prognosis, and recommendations for the welfare of the species. Chapters are written by experts on the various species and will be helpful to students and practising scientists. Each chapter includes a bibliography.

I highly recommend this book (and its two predecessors) for those interested in the complex and sometimes discouraging efforts at conservation of wildlife in the United States. Together, the three volumes provide a wealth of statistics and information which would otherwise take many weeks to obtain for any particular issue. A similar publication on Canadian conservation activities would be extremely beneficial, particularly as conservation programs in this country are similarly spread among many government agencies and private organizations.

IAN D. THOMPSON

Canadian Forestry Service, P.O. Box 6028, St. John's,
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A Synopsis of the Avifauna of China

By Cheng Tso-hsin. 1987. Science Press, Beijing (American distributor, Paul Parey Scientific Publishers, New York). xvi + 1222 pp., illus. U.S. $163.

The author is a Research Professor of Ornithology at the Academia Sinia in Beijing, China. He has updated the *Distributional List of Chinese Birds* from the 1976 second edition so that this new book covers 1186 species (2129 taxa if you add subspecies). This new text is in well-written English.

Each species entry gives the name in Chinese and English (and, where appropriate, Russian too) as well as the scientific name. This is followed by the original reference and then a very short description of the breeding habitat. A list of subspecies follows, again with the appropriate references. The range is given by province, modified by a short commentary where necessary, and is preceded by a code indicating status (resident, summer visitor, etc.). Reference numbers by two early (1930s) researchers are included where available. Finally, the status is given for some but not all birds.

For 70 to 80% of the species there are 3″ x 4″ range maps. As the maps show the entire land mass of China (well over 3.5 million square miles), they are limited in their detail. The wintering range is shown in hand-drawn cross hatch. This would have looked more professional if "Letraset" or equivalent had been used. The breeding limit is defined by a boundary line and the collection locations for specimens are clearly marked with symbols.

The book has an 11-page introduction describing the vegetal and faunal regions and giving the main sources of distributional data. A table summarizes the number of species included in the three major efforts to produce a Chinese checklist to date. The 16 faunal subregions are used in a distribution table. The author also includes a gazetteer which has a very useful, full-page map showing the location of each province (and showing each author's English spelling of the Chinese name; an important point as these spellings are rarely consistent between authors). In the bibliography Cheng gives all the post-1922 Chinese references listed alphabetically by anglicized name, and all the foreign language references used in the text. The indices are in Chinese, English, and scientific names.

With such a massive work there are bound to be some problems. I expected to have some difficulty with the English names but not as much as I had. For example, *Oceanodrama leucorha* has always had "Leach's" in its name. I did find a pre-war reference to Leach's fork-tailed petrel but nowhere could I discover another author who used Fork-tailed Storm Petrel as an English name. This is even more confusing as *O. furcata* is normally called the Fork-tailed Storm Petrel (A species not listed by Cheng, but occurring in nearby Japan and therefore a potential future addition. There has already been an unconfirmed record off Fukien.) Another example that is even more confusing is *Fregata minor* (normally called Great Frigatebird) is called Lesser Frigate Bird and *Fregata ariel* (normally Lesser Frigatebird) is called Least Frigate Bird. Such inconsistencies occur often throughout the book. I suspect that *Psittacula krameri* (normally Rose-ringed Parakeet); is simply mis-typed as Rose-winged Parakeet. Also, in some cases, no English name is given although one does exist (example: *Arborophila rufipectus:* Szechwan Hill Partridge). As far as I can tell the Russian names are satisfactory.

These problems are more irritating than important. More serious are confusions in the scientific names. For example, the author lists *Icthophaga humilis plumbea* as the Himalayan Grey-headed Fishing Eagle and as a rare visitor to Hainan. I believe he means *I. nana plumbea*, the Lesser Fish Eagle. I cannot find *I. humilis* in any literature available to me but I do not have copies of Cheng's key references for this case.

Another example is probably more a reflection of the state of Chinese ornithological knowledge. Cheng lists *Pseudibis papillosa davisoni* as Black Ibis and as accidental in Yunnan. Others have given it full species status as *P. davisoni* (White-shouldered Ibis) and resident in Yunnnan. Obviously a Breeding Bird Atlas project would be exciting and useful and the taxonomists could have fun with *Pseudibis*.

I believe there are also some omissions. For example, *Turdus philomelos* is known to occur up to the NW Chinese border near Xinjiang, and is listed by others as a breeding bird in this Chinese province. At the hypothetical end of the scale the author lists (as footnotes) some unverified sightings (*Tadorna cristata* 1936) but not others (*Diomedea immutabilis* 1976). Such omissions are surprising in such a painstakingly thorough book.

Despite these shortcomings this work is a very important contribution to ornithological literature. It will stand as a reference for many years to come. It will be indispensible for all doing research in this area, providing they exercise caution as outlined above. Cheng and his colleagues are to be commended for the immense effort they have put into the book and for publishing it in English. I hope museums, research institutes and universities will not be deterred by the high price, but will regard it as a long-term investment.

ROY JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

Waterfowl: An Identification Guide to the Ducks, Geese, and Swans of the World

By Steve Madge and Hilary Burn. 1988. Houghton Mifflin Company, Boston. 298 pp., illus. $55.

When Peter Harrison produced *Seabirds* he achieved two things. First, he provided the first top quality identification guide to a neglected area of ornithology. Second, he set a new book style that has now been followed twice. His first successors, Hayman et al., also made a major contribution with their *Shorebirds*. Never before had birders been able to find so much up-to-date, accurate information on such a wide range of plumages for a difficult-to-identify group of birds. Madge and Burn have now also followed this formula. But their choice for a bird group, *Waterfowl*, is in a very different category. Unlike seabirds which, even with Harrison's contribution, are still poorly known and unlike shorebirds, which can be exceedingly difficult to identify at times, waterfowl are well known and usually distinctive. There are, of course, some mysteries still left and some tough separations. But ducks and their allies are, by the authors admission, probably the most studied (and most painted?) group and, for the most part, sport distinctive and beautiful plumages.

As with the first two books, this one starts with a brief introduction which is followed by the 47 plates. Normally, three species are covered by each plate. As before, a range map and a brief description of habitat and major field characteristics are given on the left-hand side and the plate itself is on the right. All the world's 154 species of ducks, geese, and swans are depicted. Hilary Burn, the artist, has done an excellent job which is on par with Harrison's *Seabirds* (rather than the detailed feathering used by Hayman). My one criticism is that most of the flight illustrations are too stocky. The artist has lost some of the elegance of the flying birds. This is a minor comment. More important, she has illustrated accurately, which is critical when identification is difficult. (For example the female scoters and goldeneyes).

The maps, though small at 1½″ by 2″ are clear and easy to follow. The scale is varied to give the best information. That is, wide-spread birds (Mallard) are shown on a world map and more localized birds are shown on as large a scale as possible.

The text follows the plates. Written by Steve Madge, it is divided into the following sections: field identification, voice, description, bare parts, measurements, geographical variations, habits, habitat, distribution, population, and references. The use of boldface type makes finding the desired place in the text simple. The text is clear and concise and for the most part error free and complete. There are imperfections. For example Madge says for Barrow's Goldeneye "Females . . . all yellow bill, a feature not recorded in eastern populations which have bicoloured bills." Females in Eastern Canada normally have all yellow (or pinky-yellow) bills. Perhaps the bicoloured bill is found in the small non-migratory Icelandic population. The range maps being small are difficult to interpret but seem to be optimistic in some areas. (Red-crested Pochard in France, for example).

The descriptions of difficult-to-separate species are excellent and up-to-date and are often supported by line drawings. The reader should find this information useful in the field. Geographical variations are well described and, where valid, are given as a separate, full entry. There are some useful notes on hybrids and these may explain the "green-headed" Lesser Scaups that I have seen once or twice. I found the sections on populations particularly interesting as they are written from a global perspective, and, because of the books format, a species can be easily compared to other species.

Despite my comments that this book does not represent a major stride forward as did *Shorebirds* and *Seabirds*, there are compelling reasons to buy this book. It is well written, current and accurate, and the illustrations are first rate. It brings together all the species in one book, and it is the third in a set. It will make a fine gift for the birder who has almost everything. Now we can speculate on, and look forward to, the next volume in the series.

ROY JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

Biology and Conservation of Northern Forest Owls: Symposium Proceedings. 1987; Winnipeg, Manitoba

Edited by R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre. 1987. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM 142. Fort Collins, Colorado. 309 pp., illus.

While the subtitle "Symposium Proceedings" may suggest just another highly technical conference summary geared only to the scientific specialist, *Biology and Conservation of Northern Forest Owls* is a varied and interesting blend of the contributions of academic scientists, resource managers, naturalists, and owl lovers. International in scope, it represents a compendium of current knowledge on 15 of the 22 "northern forest" owls from 10 countries. In total, 52 papers were presented; the majority relate to owls native to Canada. For this reason alone, this document should be in the libraries of all forestry/wildlife resource managers in Canada.

Very few wildlife management agencies currently manage specifically for owls and owl habitat. Fewer still employ owl managers. This symposium thus provides a valuable service by synthesizing available knowledge related to owl biology and management. As pointed out by Monte Hummell of the World Wildlife Fund in the opening address, owls are generally managed only when they become rare or endangered, although the primary management goal should be to prevent owl species from being placed on the endangered list.

The symposium "special papers" lead off the proceedings; these put the conference in perspective through the introductory remarks, concluding summary, the plea for owl management, a discussion on the operation of The Owl Rehabilitation and Research Foundation, and a comprehensive 35 page keynote address on the "Evolution, structure, and ecology of northern forest owls". This introductory session is followed by a session related to "special aspects" of northern forest owls, including distribution, literature review, predator-prey cycles, sexual dimorphism, et cetera. Also included are sessions dealing with the biology of specific genera of owls, including *Strix, Surnia, Aegolius, Bubo, Asio,* and *Otus.* Owls of interest to Canadians are featured prominently in the text, perhaps not surprising because of the site of the conference, but many papers also represent European research interest. The circumpolar Boreal (Tengmalm's) Owl received the most attention as a featured species, with 6 papers devoted to it and 14 referring to it. The Great Gray Owl was a close second, with 6 and 12 papers respectively.

As with all symposium proceedings, this is not a book that most would pick up and read from cover to cover. However, it is possible to open it almost anywhere and find interesting reading for both the scientist and the naturalist.

If the published proceedings could be said to have a flaw, it would be the relatively low number of papers with practical management suggestions, a reflection of the current status of owl management and research in the world. The final papers in the proceedings summarized information gleaned from four workshops on capture, telemetry, management, and census techniques.

While these chapters provide useful information on techniques, it appears that in some cases, such as management techniques, far more was discussed than was eventually published in the proceedings. Other discussions on owl management techniques can be found throughout the papers, including forest management, the use of nest boxes for Barred Owls, and the use of nesting platforms for Great Gray Owls.

The publishing quality of the document deserves a minor criticism. The variable typescript in individual papers is slightly irksome, the figures and photographs vary substantially in quality and effectiveness, and it is doubtful that the softcover will withstand repeated reference use well.

This is a valuable addition to a wildlife resource library. It provides a summary of the current owl literature and science, integrates the contributions of professional and amateur owl researchers, and provides an international impetus for further owl research and management. It is a significant achievement to have such a conference held in Canada.

TED (E. R.) ARMSTRONG

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Biology of New World *Microtus*

Edited by R. H. Tamarin. 1985. Special Publication No. 8. American Society of Mammalogists, c/o University of Minnesota, Museum of Natural History, Minneapolis. 893 pp., illus. U.S. $55.00.

This weighty volume has as its model the successful publication in the same series, *Biology of* Peromyscus (King, J. A., Editor. 1968 Special Pubication 2, American Society of Mammalogy. Like its predecessor in its time, *Biology of New World* Microtus presents the reader with a synthesis of the current state of knowledge of the genus.

The book comprises 21 chapters written by 25 specialists and students of the taxon. The contributions cover all major aspects of the biology of *Microtus*, including the fossil record, taxonomy and systematics, zoogeography, anatomy, ontogeny, ecology, behavior, population dynamics, physiology and genetics, as well as laboratory management, and pathology.

Most of the chapters summarize and review results of previous studies, but some, like the chapter on Microanatomy (by Carleton J. Phillips), contain predominantly new information. The chapter on taxonomy and systematics by Sydney Anderson is an excellent synopsis of current understanding, problems and needs in this area and shows that there is still much to be done. While most authors regard *Pitymys* as a synonym of *Microtus*, Richard J. Zakrzewski (The Fossil Record) considers it a valid genus.

A quick survey of the contents of the book reveals that our current knowledge of the biology of New World *Microtus*, comprising some 20 species on this continent, is derived predominantly from the study of half a dozen species with the widespread *M. pennsylvanicus* in the lead by a wide margin. The other species are in approximate order of importance — *M. montanus, M. californicus, M. longicaudus, M. oeconomus,* and *M. ochrogaster*. It is clear that the majority of the species remain poorly known and there is thus lots of room for further work. All in all, this book makes a major contribution to the literature of *Microtus* and is a valuable source of information that cannot be ignored by those interested in the genus or in microtines in general.

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The Tanagers: Natural History, Distribution, and Identification

By Morton L. Isler and Phyllis R. Isler. 1987. Smithsonian Institution Press, Washington. 464 pp., illus. + plates + maps. Cloth U.S.$70.00; paper U.S.$49.95

The 242 species of tanagers treated in this book belong to a song bird (Oscines) assemblage of relatively small size, in which weight ranges from about 10 to less than 115 grams. Many species are brightly colored, but in some the plumage can be relatively dull. This diverse group of Neotropical origin belongs to the subfamily Thraupinae of the family Emberizidae as proposed in current classifications, but current and future research on the relationships of the family and subfamilies may eventually provide information for a different classification. In spite of the uncertain taxonomic position of a number of genera or species, the authors have followed the classification of the *Check-list of the Birds of the World,* Volume XIII (R. A. Paynter. Editor. 1970. Museum of Comparative Zoology, Cambridge, Massachusetts).

Only two species of tanagers are known to breed in Canada, the Scarlet and Western tanagers, which are among the most brightly colored members of the group. Naturalists or bird watchers who have never had the opportunity to look at tanagers as a group or whose experience with these birds is limited to the two species found in Canada will be surprised at the great diversity of coloration patterns, colors, or lack of colors of these birds, when leafing through the 32 color plates assembled in the center of the book.

All these plates were drawn by the first author. The quality of the drawings is good and the color reproduction fairly accurate. If one expects to find drawings equal in quality to those of the better field guides, one can be somewhat disappointed even if the plates are of good quality. In spite of this criticism, they are well organized, precise, pleasant and, above all, useful. All the species of the group are depicted, even the Green-capped Tanager (*Tangara meyerdeschauenseei*) described in 1985. Facing each plate (on the left side of the open book), a short text gives the scientific name of the species, which is identified by a number on the plate, the english name, a capsule summary of the range, identification marks in telegraphic style, and the page number for the full information on that species.

The book contains, in addition to a foreword, an introduction of 39 pages that deals with several topics such as objectives, acknowledgments, sources, plan of the book, abbreviations, glossary, schematic of species accounts, and the nature of tanagers. This section is followed by the most important part of the book, the species accounts (pp. 41-373), references (pp. 374-391), and an index (pp. 393-404). There are in addition, interspaced throughout the text, 27 tables that provide various types of information of interest but those in which the species of a given genus are listed are particularly useful.

Each species account varies in length according to the amount of information available primarily from the literature, but all of them contain information arranged in a standard pattern: length, weight, subspecies (if any), differences not shown in color plates or described in the text, breeding in the subadult plumage, geographic range in summary, elevation, habitat, behavior, vocalizations, breeding, and sources. In addition, the range of each species is given on a range map where the known distribution is clearly indicated. The size of the maps varies much according to the range of the species treated but, in all cases, it is very easy for one to orient oneself.

The text comprises two sections for those species that breed in North America, such as the Scarlet Tanager: one dealing with the boreal summer, in which the sections listed above are covered to a significant extent with the breeding range (no map); and in the other section entitled "In Boreal Winter", the same topics are covered. It is under the latter section that a geographic map is given to show the range on the wintering grounds.

I found the information of all the sections to be very up to date and summarized accurately. The authors have succeeded in condensing in a small space a great deal of information from many sources. By going through this book, one can easily identify the least known species, which may provide a good incentive for future field studies to those who travel in the neotropics.

This is a book which I strongly recommend particularly to all those who may be travelling to Central or South America in search of tanagers, as well as to those who are interested in neotropical birds in general. It is a very good book well worth its price.

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Populations and Breeding Schedules of Waders, *Charadrii*, in High Arctic Greenland

By Hans Meltofte. 1985. Meddelelser om Grønland, Bioscience 16, Copenhagen. 44 pp., illus.

and

The Avifauna of Central Northeast Greenland, 73°15′ N-74°05′ N, Based on a Visit to Myggbukta, May-July 1979

By Magnus Elander and Sven Blomqvist. 1986. Meddelelser om Grønland, Bioscience 19, Copenhagen. 44 pp., illus.

These publications comprise two issues of Meddelelser om Grønland, *Bioscience*, a publication of the Commission for Scientific Research in Greenland. Each deals with aspects of northern Greenland's avifauna, presenting original research and summarizing a wide body of knowledge from numerous sources not easily accessible to North American biologists.

The first publication, by Hans Meltofte, focusses on shorebird populations at 13 coastal localities in northern Greenland and one adjacent Canadian site, at Lake Hazen, Ellesmere Island. The author makes extensive use of previously published literature from these sites, as well as a considerable body of data that he collected while working at weather stations and on numerous expeditions. The objective was to understand how breeding phenologies and population densities of shorebirds are influenced by local topography and climate. Thus, rather than summarizing breeding biology of the individual species per se, the author integrates information from the nine shorebird species into general discussions of annual cycles and distributions. Spring and fall migration are covered in considerable detail, providing a good perspective on this problem.

The picture that emerges is that densities and breeding schedules are generally correlated with the percentage of snow-free ground in spring and with vegetation cover. These factors do not produce a simple cline of early breeding and high density from south to north, however, because they run in opposite directions. In the north there is a low accumulation of snow, which results in these areas becoming available for nesting earlier, whereas population densites are highest at lower latitudes where vegetation and food are more abundant.

On the whole, the author presents a fairly convincing case, but conclusions are necessarily tentative due to the nature of the data available. Most of the information is based on visits during one or a few days in a single season at each site. The Arctic is notorious for annual variation in numbers and breeding biology of its inhabitants, and this has undoubtedly weakened the latitudinal comparisons. Not all of the data are readily comparable, since other researchers had often used different census techniques or visited the sites at different times of the season. But the author compensates as much as possible by standardizing data on vegetation and snow cover. He also supplements the data on the 14 sites with published information from other areas, including many studies from northern Canada. Data on ecological conditions faced by the birds are illustrated by 16 large black-and-white photographs.

Elander and Blomqvist's publication differs from Meltofte's by focussing on all breeding birds at one particular locality, Myggbukta, two-thirds of the way up the eastern coast. This former weather station has attracted biological expeditions since the 1930s. The 6.1 km^2 site is a coastal plain pock-marked by numerous ponds and surrounded by a system of beach ridges.

During one summer the authors recorded 38 species of birds, 14 of which bred on or near the census area. The status of each species is summarized and records are reviewed for an additional 19 species reported from previous expeditions. Particularly detailed accounts are provided for King Eiders (*Somateria spectabilis*) and Oldsquaw (*Clangula hyemalis*).

As with Meltofte's work, one is left with the impression that Elander and Blomqvist have done everything they could with the limited census time available. They took a somewhat eclectic approach to data collection. For example, they made one continuous 24-hour time budget study of flocks of foraging Dunlin (*Calidris alpina*) and sampled the prey available to the birds. On another occasion they placed a pair of King Eiders under 24-hour surveillance to count the number of times the birds copulated (three). Such anecdotes are included in the detailed species accounts, which are supplemented by several tables indicating geographic variation in aspects of breeding biology. The authors close with a brief discussion of feeding niche separation by four species.

Elander and Blomqvist's publication complements Meltofte's because, whereas Meltofte is concerned with geographic variation in one group of species (shorebirds), Elander and Blomqvist focus on all species occurring in a small area. The authors of both publications make it clear that many of their ideas and interpretations are still tentative. This is unavoidable in a region where the data base is derived primarily from sporadic visits by scientists to a limited number of locations, often for reasons not connected directly to ornithology. Together, though, the publications yield a strong synthesis of new information and previously published literature. This is particularly relevant to Canadian biologists, since 80% of the species occur in our country as well.

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Population Ecology of The Cooperatively Breeding Acorn Woodpecker

By Walter D. Koenig and Ronald L. Mumme. 1987. Princeton University Press, Princeton. xiii + 435 pp., illus. Cloth U.S.$55.00; paper U.S.$16.96.

Communal or cooperative breeding in birds is a phenomenon receiving increasing attention from ornithologists. Hot on the heels of Glen E. Woolfenden and John W. Fitzpatrick's 1984 study of the Florida Scrub Jay (*see* 1986. *Canadian Field–Naturalist* 100 (3): 447-448) which exhibits this behaviour, comes a lengthy and detailed work on one of the most fascinating co-operative species, famous for its storage of acorns in selected trees as granaries. The authors set the stage with a historical perspective on avian "communism", the natural history of the woodpecker, the theoretical framework of adaptive evolution, and descriptions of their methodology and study population. With the importance of the granaries established, aspects of reproductive success are examined, including early sources of mortality such as hatching failure and nesting starvation. Throughout the book, a number of issues which are of great contemporary interest in the behavioural ecology of birds are considered. Two of these are sexual conflict, which is intense in this species in such respects as the optimal composition of a breeding group, and parental manipulation of the sex ratio of clutches, for which there is no evidence.

Succeeding portions of the book deal with major subjects including dispersal of young, consequences of territorial inheritance, demographic and regulatory aspects of the population, and features of sociality including the retention of offspring in a territory and sharing nests and mates. Females disperse further than males, who are more likely to inherit their natal territory. Parental birds do not appear to favour some offspring as heirs over others. The demographic analysis is made complicated by such features as multiple breeders and reveals considerable opportunity for the operation of natural selection. Survivorship of the two sexes is differentially affected by the composition of the breeding group. Food is a primary factor limiting the number of breeders, the total size of each breeding group, and the number of groups in a population. Much evidence indicates the greater fitness of dispersing rather than nondispersing and helping, and the ecological constraints which limit such dispersal. The authors conclude with a review of their findings and outstanding issues.

This volume is an excellent addition to the prestigious Princeton series. It includes copious details given in a flowing and lucid style with plentiful figures and tables accompanied by comprehensive referencing and indexing. The authors provide an extensive presentation of their own data and comparison with other studies. Their work again illustrates the value of long-term field studies in behavioural ecology. Particularly helpful is the focus on curious findings which require special consideration. These include such intriguing findings as (1) the fact that breeding success depends heavily on stores of acorns even though these stores are a small fraction of the total energetic budget of a breeding group and are not fed to nestlings, (2) nestling survival is unrelated to the abundance of the insects upon which they are fed, (3) although helping is presumed to have evolved due to ecological constraints on the opportunity to disperse and breed, almost all birds surviving to their first spring do eventually breed, and (4) while analyses indicate that males sharing mates have higher reproductive success over their lifetime than those breeding alone, more than a fourth do breed solitarily. The unraveling and interpretation of these observations provide the conceptual heart of the book.

Notwithstanding the thoroughness of their presentation and their adaptationist stance, the authors candidly and surprisingly admit that for both the Acorn Woodpecker and the equally intensively studied Florida Scrub Jay it is possible that there is no selective advantage to helping and that rather it is misdirected parental care. This hypothesis surely bears further discussion and its persistence reflects the amount of work remaining, especially on the mechanisms underlying helping behaviour, and the complexity of these phenomena. Overall, this book will be of interest to a broad spectrum of animal ecologists and ornithologists.

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Time & Life: Fossils Tell the Earth's Story

By George E. Lammers. 1986. Canadian Album Series; Nature Stories for Children. Hyperion Press, Winnipeg. 40 pp., illus. $4.95.

This is one of a series of eleven large-format (9 x 12 in) books presumably intended to inform children about the kinds and appearances of plants and animals that have been recorded through geological time in North America. The other books deal with living animals and plants.

Lacking any statement concerning the specific audience and goals of this book, I presume it is intended for those between the age of about seven and twelve years. A series of full-page outline sketches of Precambrian to Ice Age scenes (Pleisto-scenes?) indicate that this is a colouring book (and some earlier books in the series have the subtitle "A Coloring Adventure in Canadian Themes"). If so, the text, in small, dense print with a generous sprinkling of polysyllabic words and technical terms, is out of synch: parts would challenge university students. For example, "The Dunkard Group of rocks in Ohio, West Virginia and Pennsylvania is composed of red siltstone and shale and some limestones and coalbeds" (p. 18). Such statements need "translation": for this and adjoining sentences I would suggest something like "The only known Permian deposits in eastern North America are from south of Lake Erie". The editor, at least, should have caught: "Culminating in the Taconian disturbance" (p. 8); and the term "chitinophosphatic" (p. 14).

The book begins with an interesting discussion of geological time and a geological time scale that does not always conform to the time used in the rest of the text (e.g. on p. 32 the Miocene epoch "occurred 29 to 7 million years ago" (22 m y) whereas the time scale on p. 3 indicates that the epoch lasted from 26 to 7 million years ago (19 m y), and (near the bottom of p. 32) the Miocene is said to cover 19 m y. Following this, two pages are usually devoted to each period (or epoch in the Tertiary and Quaternary). The left page gives: (a) a paragraph describing the appearance of the North American continent then, inland seas, prevailing climate, type of deposits; (b) a paragraph on characteristic animals and plants of the period; (c) a map of North America showing changes in topography — ancient land and sea masses and mountains; (d) small graphics showing details of a few characteristic species; and (e) a detailed caption describing a large outline drawing (opposite) of a typical scene of the period (e.g. showing Cambrian "marine beetles" (trilobites) on p. 7 and large plant-eating dinosaurs (*Apatosaurus*) on p. 22 and the cover. Where many different species are shown (e.g. the Ordovician scene on p. 8) it would be handy to have a transparent overlay page with specific identifications on it; but perhaps this was impractical for economic reasons.

The large outline illustrations (by Betsy Thorsteinson) on the right-hand pages are usually clear, appealing and well arranged: they would be fun to colour. However on p. 13 the nearest "lobe-finned" fish (*Holoptychius*) has its eyes too far back — more like the shark near the bottom of the page. Her paintings of ice-age scenes produced in black and white on p. 39 show a marked change in style with the rest of the illustrations. Certainly they are didactic rather than realistic: normal scenes would have fewer animals! The book closes with a list of additional reading.

Many errors crop up in the text, some probably typographical (e.g. trilobites not "tulobites", Arachnids not "Arachnides", *Apatosaurus* not "*Apatasaurus*", *Paleocastor* not "*Paleocaster*", Creodonts not "Creodents", *Asinus* not "*Assinus*", etc.). More serious problems include: meteorites rather than "meteors" explode on the mantle's surface (p. 4); although all other Cretaceous leaves are identified (p. 24), the one on the left is not; the tulip tree (p. 26) is *Liriodendron* not *Lirio* *dendron*; no maybes, we *are* in an interglacial (p. 36); great quantities of sediment were transported eastward (not "westward") from the Rocky Mountains as a basis for the Cypress Hills (p. 30); although *Brontotherium* (p. 30) is said to be the largest land mammal ever found in North America, there seems to be competition with *Moropus* (also said to be 2 m high at the shoulder (p. 32). Further, but normally regarded as "horse-size" in paleontology texts the Canadian Arctic Islands (and recent interesting findings of Tertiary fossil forests and vertebrates, such as alligators, made there) are completely neglected on the maps and in the text. This is unfortunate in a Canadian book. Also woolly mammoths are not using their tusks to clear snow as stated in the caption on p. 36. In the Pleistocene portion, it would have been useful to show a map of the maximum extent of glaciation, as well as dotted outlines showing the greatest extent of glacial Lake Agassiz and the Champlain Sea (a major post-glacial geographic feature of eastern North America not mentioned in the text).

George Lammers has produced an interesting, data-packed sketch of water, land and life on this continent during the last 4.5 billion years of earth history, but I think that the message would fail to reach many (other than highly gifted) children. Certainly, it is important that scientists continue to provide clear summaries of important findings in their fields to non-experts, including children.

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Treasures of the Tropic Seas

By René Catala. 1986. Translation of: Offrandes de la mer. Facts on File, New York. 334 pp., illus. U.S.$50.00.

In 1956, Dr. René Catala founded the Aquarium of Noumea. For the next 20 years he and his wife collected, nurtured and studied the inhabitants of the tropical lagoons at their doorstep. At the same time they accumulated quantities of photographs and observations of their aquarium "guests". It is these that are presented in this book.

Treasures of the Tropic Seas professes to present a "kaleidoscope of marine organisms". This indeed it does, through anecdotes and a multitude of colour photographs. It tells us how a squid fillets a fish before eating it; of the aggressively destructive behaviour of the mantis shrimp and of its endearing habit of "sitting" on its abdomen. The decorator crabs obsessively disguise themselves by attaching algae, sponges, corals, or even bits of coloured paper all over body and legs; and the fantastic shrimps *Hymenocera elegans* — looking like the richly caparisoned horses of knights in armour — nibble at live starfish, only moving on to a new source of food when the old one gets too small to stand on! And we learn about the little fish, called by the author *Gergobius taeniura*, that clean out their sand house each morning and rebuild it each evening. The observations are accompanied by a quantity, at times almost a surfeit, of photographs, many of quite spectacular organisms, culminating with that of a crinoid perched on a sponge growing on a scallop sitting on a helmet shell.

The author also speaks out on topics related to his aquarium interests. His concern for the animal both as an individual and as a member of a community is refreshingly unsentimental, but many of his comments betray his lack of scientific fundamentals. Thus, he asserts that the name *Dactyloptena* is misspelled, as it must be derived from "pteron" (wing). It could just as well derive from "ptenos" (winged); and even if originally misspelled it still has to be retained according to the rules of nomenclature. However, when Dr. Catala expresses his anger at the desecration caused by traffickers in shells through their wholesale destruction of an area, we can only agree. The need for conservation measures to protect the beauties of nature, whether shell, coral or bird, butterfly and beetle, is urgent and may indeed be too late for some species.

Unfortunately, Dr. Catala has been poorly served both technically and by his translator and editors. He has an unsophisticated style of writing with an archness that I found tiresome. However, this cannot excuse the convoluted misuse of English in the translation, nor the poor editing. There are just too many sentences that are grammatically or semantically incorrect or wholly mistranslated: "The time of molting always takes place in the second half of the night . . ." and "We had to place a fine net against the three concrete sides of the tank to avoid these 'guests' wearing out their rear ends . . ." and "Clown-fish . . . fascinating symbiotic hosts of sea-anemones . . ." are readily found examples. Also unforgivable is the use of misspelled (Hyroïdia) and incorrect (Placophora for the chitons) scientific terms and names. The translator appears not to have been provided with any source for scientific terminology; and the editors have not checked scientific names, so that different spellings for the same genus occur within a few lines (*Camposcia*/*Composcia, Gomphia*/*Gomophia,* etc). Finally, many of the photographs, some of marginal quality to begin with, suffer from poor colour separation and are thus as irritating as the text.

Treasures of the Tropic Seas has the dimensions of a coffee table book, at 2.5 kilos and 25 x 30 cm format. This makes it physically hard to read, though I am sure that the author considered the text as important as the photographs. It is the sort of book that could clearly demonstrate how the observant amateur can contribute much to science. Unfortunately, the information it contains is too anecdotal and too poorly presented to be of much significance. With its many shortcomings and considerable price, I am unable to recommend it to any but the most ardent tropical naturalist.

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Bumblebees

By Oliver E. Prys-Jones and Sarah A. Corbet. 1987. Naturalist's Handbook 6. Cambridge University Press, Cambridge. 83 pp., illus. + plates. U.S.$24.95.

Bumblebees are charming insects. This book makes them merely interesting. I once served as joint supervisor for an honours thesis on aspects of foraging behaviour of bumblebees. Watching the student work with her bees in Chris Plowright's flight room at the University of Toronto, I was struck by her intimate knowledge of them as individuals and could easily believe that she had wept with grief when one of her "best" queens died. You will find no such anthropocentric nonsense in this austere little book.

Nor will you find any North American bumblebees. Unless there have been some recent sweeping revisions of bumblebee nomenclature, all the species described in this book are British. In any case, there is a warning for aspiring taxonomists that the dominant diagnostic of hair colour varies geographically and that "features of coat colour used in the keys are not necessarily appropriate when identifying bumblebees from outside Britain and Eire."

This is in no way a criticism of the book, which is explicitly addressed to British students and amateur naturalists. The authors, both on the staff of the Department of Applied Biology at Cambridge, are clearly authorities on the Hymenoptera in general and bumblebees in particular. In conformity with the objective of the Naturalists' Handbook series, this is a proselytizing book, designed to recruit amateur naturalists to serious studies of bumblebees by pointing out gaps in our knowledge and providing the techniques for exploring them. Amateur naturalists are clearly valued in Britain.

So, much of the book is inappropriate for Canadian naturalists. Still, chapters on the natural history of true bumblebees (*Bombus*) and cuckoo bumblebees (*Psithyrus*) contain material of general interest. So, too, does the authoritative and up-to-date chapter on foraging behaviour. This chapter begins with a consideration of "optimal foraging theory" but with the caveat, ". . . it is important to bear in mind that this mathematical treatment of biological systems requires simplifying assumptions . . . and requires, perhaps, a deeper understanding of bumblebee biology than is yet available." And again, the proselytizing theme emphasizing that ". . . major theoretical advances will depend on patient observational studies of natural history."

True grist for the amateur's mill is a chapter on nests and their establishment in captivity, which sounds like great fun. The terminal chapter on "Techniques and approaches to original work" assumes the seriousness of the coterie of British naturalists — ready to read the original literature, equipped with a species intimacy with British flora, and with a dissecting as well as a compound microscope and at least one refractometer. One cannot think that the authors have overestimated their audience because Corbet co-authored a previous book in the series. From our perspective, perhaps the book should be viewed as a sociological statement of the sophistication and recognition of British amateur scientists — and an oblique comment on our own neglect of this same resource.

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Atlas of Trichoptera of the SW Pacific — Australian Region

By Arturs Neboiss. 1986. Junk, The Hague, The Netherlands (American distributor, Kluwer, Boston). viii + 286 pp., illus. Dfl. 200 (approx. U.S.$85).

The literature on Trichoptera is difficult to find, especially when one needs to work with an unfamiliar fauna. Many papers crucial to understanding a particular fauna were published 50 to 100 years ago, often in obscure journals not found in most libraries. Even after ascertaining the appropriate citations it may be a long and frustrating task attempting to obtain copies of out-of-print and rare volumes that enjoyed only limited circulation. This is why comprehensive works on regional faunas are so valuable and why the *Atlas of Trichoptera of the SW Pacific — Australian Region* is an important contribution to understanding the fauna of that region.

Like the earlier *Atlas of European Trichoptera* by Hans Malicky (reviewed in *Canadian Field-Naturalist* 98: 137–138), Arturs Neboiss' atlas brings together, in a single source, illustrations of virtually every species known from the region in question. Previous comprehensive works on the caddis fauna of the region have dealt with Australia, New Zealand and Tasmania, but none is as complete or as far-reaching as Neboiss' atlas. The principal previous comprehensive study was published in 1953 and has been rendered out of date by numerous publications in the intervening 30+ years.

The format used in this atlas is very similar to that used originally in the European atlas, but there are some differences. Most importantly, there is a key to families at the beginning of the book that replaces the table of characteristics in the earlier atlas. The key provides a more effective entry to the families than the table of the earlier atlas, and the accompanying illustrations of morphological features will prove most useful to users having limited familiarity with characters of Trichoptera taxonomy. Another significant difference is the inclusion at the beginning of each family section of a one-page diagnosis with drawings of the head and thorax to illustrate the all-important setal warts and drawings of wings to illustrate the "typical" venation for the family. Additional illustrations of distinctive characteristics are provided for several families, such as the head filaments in Calocidae, the pilifers of Philorheithridae, and the maxillary palpi fo the males of many families. This is followed by a synopsis of the genera showing the number of species in each genus covered in the following pages.

The bulk of the book consists of page after page of illustrations of genitalia. A lateral aspect of the male is included for all species, and frequently dorsal and ventral aspects as well as details. Other features such as wing venation are included where appropriate. Genitalia also are illustrated for the known females adjacent to the male of the species. Placing the female genitalia beside the male is logical and represents an improvement in lay-out over the earlier atlas, in which female genitalia were grouped together following the illustrations of the males. There are other minor differences between this atlas and the first, such as less reliance upon symbols; this helps to make it more useable than the latter.

The two atlases thus far produced by Junk are invaluable additions to the literature of Trichoptera, and I sincerely hope that the publisher is planning to continue with further atlases on the other regions of the world. I highly recommend the *Atlas of Trichoptera of the SW Pacific — Australian Region* to everyone with an interest in caddisfly systematics.

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Proceedings of the 5th International Symposium on Trichoptera

Edited by Michel Bournaud and Henri Tachet. 1987. Junk, The Hague, The Netherlands (American distributor, Kluwer, Boston). xviii + 397 pp., illus. Dfl. 250 (approx. U.S.$119.50).

Every three years the world's leading students of Trichoptera gather for a symposium to discuss the latest advances in the field, and every three years the proceedings are published in book form by Junk Publishers. The fifth such symposium was held in Lyon, France, 21-26 July 1986, and the proceedings were edited and published in 1987. Both the extent of participation in the symposium and the quality of the published proceedings have steadily improved over the years. Eighty-nine participants from 23 countries attended the meeting in Lyon. For the first time, the Far East was represented with participants from Sri Lanka, Hong Kong, the Peoples Republic of China, and Japan.

The *Proceedings* consist of 66 papers grouped by the editors under eight topic headings: Morphology and Anatomy, Taxonomy, Fossil Forms, Biogeography, Phylogeny, Biology and Physiology, Light Traps and Flight Patterns, and Ecology. The last three headings are further divided into subheadings.

The diversity of subject headings and subheadings serves as an indication of the breadth of research interests among Trichoptera workers. Three of the first five sections are rather specialized, dealing specifically with caddisfly structure, taxonomy and phylogeny. The three papers on Fossil Forms, however, will likely be of interest to paleoecologists and biogeographers. The section on biogeography is largely a review of regional caddisfly faunas, although there is a common theme among these papers of the degradation of caddisfly habitats and the need for conservation of unique and threatened aquatic habitats. These concerns, expressed by European and Asian workers, should heighten the level of awareness among North American workers for the need for a more critical evaluation of the status of unique caddisfly habitats in Canada and the United States while there still remains significant unaltered habitat in many areas of the continent.

The 11 papers under Biology and Physiology include a study of the effect of photoperiod on the maturation of female genitalia, an experimental study of mate recognition in Leptoceridae, and a summary of methods used in the study of caddisfly pheromones. Other studies explore the adaptive significance of egg-laying behavior and the respiratory adaptations of caddis larvae.

Under Light Traps and Flight Patterns the seven contributions include spatial and temporal analyses of light trap collections, as well as an experimental study of flight behavior and an analysis of geographical variation in flight phenology of several species. Twenty-four of the 66 contributions are placed under the Ecology heading, with papers ranging from single species life history studies to multivariate statistical analyses of community structure. Also included here are studies of the impacts of environmental alterations on caddisfly communities.

The editors are to be complimented for their excellent job of organizing the papers under the various subject headings. There also are author, geographical and taxonomic indexes, which make the book's contents more accessible. It is printed on high-quality paper and the illustrations are clearly reproduced. Because of the wide range of topics treated, this volume should appeal to non-caddisfly workers as well as to specialists. However, at $120 (U.S.) it is not likely to find its way on to the bookshelves of very many individuals. I recommend that those with a serious interest in Trichoptera or aquatic ecology ask their library to purchase a copy.

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Birds in Minnesota

By Robert B. Janssen. 1987. University of Minnesota Press (Canadian distributor, Beaverbooks, Markham, Ontario). 376 pp., illus. Cloth $35; paper $14.95.

Birds in Minnesota is a revised and enlarged reworking of *Minnesota Birds* (1975) co-authored by Janet C. Green and Janssen. The 1987 updated version adds twelve years of information to the knowledge of Minnesota bird life. Those twelve years added 26 new species to the state list, which, along with many other records, made a revision well worthwhile.

The book starts with a well-written foreword and preface in which the genesis of the book is described and acknowledgments are given. This is followed by an introduction to the avifauna with some comments on climate and distribution written by Kim R. Eckert, a longtime Minnesota birder. Included in next section are definitions of terms used later in the book to describe status and abundance. In the middle of this are lists of species, organized by category: regular, casual, etc.

The detailing of species by species status and migration dates occupies the next 314 pages. This section also has some information on breeding distribution, which is supplemented by maps. References scattered throughout these accounts refer primarily to articles published in *The Loon* or *The Flicker*.

The book ends with a short appendix listing three new species that did not make it into the species accounts plus a list of eleven hypothetical species. The appendix is followed by an index, which lists the birds by their common names only.

This is one of several "Birds of . . ." books now available which give a concise and accurate picture of bird life in the area they cover. The species accounts are direct and not overburdened with excessive information. The terms are clearly defined.

On the negative side, the organization of the book is not as good as the 1975 volume. The species lists in the terminology section would have been better left as an appendix. There is no selected bibliography nor references corresponding to the citations in the species accounts. Despite the widespread use of common names, an index of scientific names should be included. The colour photographs of Minnesota specialities in the cente of the book are nice but not essential to the information and probably forced the cost of printing upwards. There is always a danger the editors will let an obvious mismatching of pictures and captions slip through, which happened with the Greater Prairie Chicken and the Sharp-tailed Grouse.

The book describes itself as a "field guide" but it is really an annotated checklist and will be primarily used for reference.

Comparing the 1987 book to its predecessor of twelve years ago, one is presented with a classic example of how much bird knowledge has grown in little more than a decade. Birders in Manitoba and western Ontario interested in migration and distribution would probably find this book useful for information on what is happening just south of their borders.

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Red Fox — The Catlike Canine

By J. David Henry. 1986. Smithsonian Institution Press, Washington. 174 pp., illus. U.S.$22.50.

Jane Goodall describes this book as a ". . . masterpiece of patience and dedication . . . (and) outstandingly successful". She does not exaggerate. For anyone who experiences pleasure from watching wildlife, this book provides a renewal and a reaffirmation of that enjoyment. Even if you have only the remotest interest in foxes, canids, predator-prey relationships, animal behaviour, or approaches to field investigations (all of which are discussed in this book), you should read this account of one scientist's fascination with a wildlife species. The author summarizes fourteen years in the pursuit of an understanding of fox ecology in a volume that combines the best of descriptive naturalism and investigative science. The value of this book lies as much in the author's careful accounting of his thinking about the complex questions he faced as with the information he collected and the conclusions he derived. Its value is enhanced by his clear writing style and the insights it provides into the thought processes of a scientist trying to understand an animal different from ourselves.

Every researcher brings a particular perspective to the questions asked and the clue to Dr. Henry's approach is in the title: that the fox while classified as a canine and showing aspects of canine behaviour in its hunting methods also displays certain catlike behaviour. The observation of such catlike behaviour results from the author's years of painstaking observations of fox behaviour in the wild, and the question that he constantly returns to is "How could this behaviour have evolved in a canine?" To lead us through his thought processes in dealing with this question, the author juxtaposes details of his field studies (sometimes including direct quotes from his field notes) with research from other studies and his thoughts on trying to connect theory related to fox ecology with results from both.

He begins by sketching in the main aspects of fox ecology, describing the fox as a hunter of small prey and an opportunistic scavenger. This flexibility in behaviour reveals a highly adaptable species capable of occupying many different habitats. Henry trys to understand what "fox" is by examining its diet. He links the solitary hunting nature of foxes to the small size of their prey and attributes their behaviour of silent stalking of prey to the highstrung nature of those prey. He relates the dawn-dusk activity patterns of the fox directly to the dawn-dusk activity of their prey and argues that they occupy edge habitats because those habitats are more varied in prey. The result from the latter observation is that as humans continue to create more edge habitats by fragmenting once-continuous communities there are more prey of the type foxes hunt (small rodents, rabbits, insects) and therefore more foxes. He briefly examines parenting behaviour, monogamy and the strong pair-bond in foxes and provides interesting speculation on the lack of physical differentiation between dog and vixen foxes. Again in a brief discussion, he reviews the growth of pups to adulthood, the behaviour of both parent foxes in helping to raise the young, the organization of fox populations into small family territories, and the dispersal strategy of newly adult males and females. All of these relationships are tied together in a series of flow charts that make explicit their interconnections. For example, the knowledge that the fox is an opportunistic scavenger and hunter of small prey helps to understand why both foxes help to raise offspring which in turn leads to understanding why a strong pair bond develops between adult foxes which in turn leads to an explanation of little sexual dimorphism between adults.

From this background sketch, the author brings us into Prince Albert National Park and the world of his field studies. For anyone involved in field studies of wild animals, these chapters that expand on the earlier background chapters are a particular delight. The author painstakingly watches and tracks the foxes, constantly questioning their behaviour; he reveals his wonderment about these behaviours and, like a detective searches for the clues that will lead to some answer, he devises experiments in which he tries to simulate fox behaviour. This leads the reader through a fascinating recounting of those years in the field and the excitement as first glimpses of possible explanations present themselves.

The book is liberally provided with black-and-white photographs, sketch diagrams, charts, and tables with one of these at least on every second or third page. In addition, eight pages of magnificent full-colour photographs are provided at the beginning of the book. The author provides additional notes on intriguing points in each chapter at the end of the book; these are keyed into information on specific pages. The notes should not be ignored; they provide some fascinating insights and additional information. A detailed bibliography of 400 references is provided and includes material ranging from 1880 to as recently as 1985. An index (which every book should have but many do not) concludes the book.

A number of the chapters have been previously published as articles in journals. As separate articles they contained some duplication of information so that each article could stand on its own. Not all of that duplication was removed in using these articles as chapters in this book and therefore there is somewhat of a feeling of deja vu in reading certain paragraphs in different chapters. On the other hand, for those who do not read an entire book in one sitting, some replication of information helps to retain the major elements of the book. If there is a weakness to this book, it is the inevitable one that comes from the letdown when the final page is read and we have to leave David Henry's world and the world of the fox.

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Frogs and Toads of the World

By Chris Mattison. 1987. Facts on File, New York. 191 pp. $26.95; U.S.$22.95.

There have been only a few attempts at covering the biology of frogs and toads. In fact, there are only a few books that exclusively deal with amphibian biology, the most recent, outstanding contribution being Duellman and Trueb's *Biology of Amphibians* (1986, McGraw Hill). Most books on amphibians emphasize taxonomy and distribution while few consider details of life history and physiological ecology. Therefore, *Frogs and Toads of the World* was an enticing title, especially if one is looking for an introductory book.

The book is divided into 11 chapters: (1) "Frogs or Toads?"; (2) "Design — size, shape and colour"; (3) "Physiology — interior design and function"; (4) "Staying Alive: enemies and defence"; (5) "Food and Feeding"; (6) "Reproduction 1 — the mating game"; (7) "Reproduction 2 — development"; (8) "Life-histories"; (9) "Distribution and Movement"; (10) "Frogs and Man"; and (11) "The Families of Frogs". A brief bibliography and an index are also provided. The colour plates are, for the most part, some of the best ever published.

My initial overall reaction to this book was very positive, admittedly because of the colour plates. A closer examination, however, showed much to be desired. At times, the writing is convoluted and difficult to follow. In the first paragraph of Chapter 1 we read that "The early amphibians . . . begin the colonization of the land, about 350 million years ago (. . .). They still retain a close affinity with water, having glandular skins, . . ." The beginning pronoun in the second sentence, "They" refers back to the phrase contained in the parentheses, which refers to modern amphibians. There are numerous verb agreement problems and run-on sentences. Just how bad are the grammar and syntax? The publisher's "news" release notes that "Toads primarily belong to one family, Bufonidae. They have tails, . . ." After reading the text I began to understand the source of confusion. Athough Mattisons never makes the statement that toads have tails, his style of writing is quite convoluted and unclear.

The book appears to have been hastily put together. It would have benefitted greatly from professional editing. The first reference to a figure occurs in Chapter 1 and this refers to "fig. 15, page 101", which is actually found on page 100. Plate 63 appears to be rotated 90° counter clockwise and plates 99 and 100 are reversed. *Petropedetes* is consistently mis-spelled as *Petropedates, Baleaphryne muletensis* is referred to as *Alytes mulatensis* (incorrect spelling of *muletensis* in the index only). *Arthroleptella hewitti* and *A. lightfooti* are placed in the wrong genus, *Arthroleptis*. The latter has been proposed to belong to a separate family and appears as such in *Amphibian Species of the World* (edited by Frost 1985); Duellman and Trueb accept it as a subfamily. References to *Anotheca coronatum* refer to *A. spinosa. Numerous* other errors occur.

My overall evaluation is that this work is not very good. I could not recommend that every naturalist purchase the volume. For the knowledgeable naturalist who will be alert for authors' errors, the book provides an adequate overview of frog biology. Some interesting data are brought forth to the popular literature from the more technical writings. Experts will have a far easier time unscrambling the grammar but they are better off with Duellman and Trueb's volume unless they want to have access to some great colour photographs. I would not recommend that *Frogs and Toads of the World* be purchased for or by the novice, especially the young. Unfortunately, it is this very audience that the book was undoubtedly intended.

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Hoverflies

By Francis S. Gilbert. 1986. Naturalist's Handbook 5. Cambridge University Press, Cambridge. 66 pp., illus. + plates. U.S.$17.95.

This Naturalist's Handbook, *Hoverflies*, describes common members of the order Diptera, family Syrphidae found in the British Isles.

The main objective of the author is to provide a source of information as well as requirements for further study by amateur entomologists of this interesting group of flies. This has been achieved, I feel, in several ways. The reader encounters an easy-to-read text with few technical terms. The few technical terms that occur are simply defined. Easy-to-use illustrations are provided throughout the text for identification of body parts and species. Francis Gilbert has also provided a list of questions that need to be answered for this family of flies. There is also a list of references provided for those that wish to obtain further and more detailed information.

One problem I encountered with this book is that it is of common British hoverflies. I found that not all the species listed are to be found in Canada. The second problem arises from the first. The reference list is for species found in Britain and therefore important Canadian references such as J. F. McAlpine's *Manual of Nearctic Diptera* are not mentioned.

To sum up I feel Francis S. Gilbert has written an easy-to-read and informative book on British hoverflies, some that are found here but not all, for the amateur entomologist.

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Cutthroat: Native Trout of the West

By Patrick C. Trottier. 1987. Colorado Associated University Press, Boulder, Colorado. 219 pp., illus. U.S.$25.

Patrick Trottier shares with the reader his knowledge gained through 30 years of fishing and studying the Cutthroat Trout as well as reading the scientific literature and conversing with experts. The book is the story of the Cutthroat Trout, its forms, evolution, distribution, life history, habitat, exploration by man, and the fish's future. The book is written for the fisherman, but will appeal to anyone concerned about nature. Although not intended as a how-to, where-to manual to catch cutthroats, information provided on distribution within watersheds, size of fish, feeding habits, and habitat is more than sufficient for even an uninitiated easterner such as myself to pursue a trophy fish.

The book is very well written. Complex topics such as taxonomy, electrophoresis, evolution, and zoogeography are described in a straight-forward fashion that will present little difficulty in understanding. The first two chapters are an overview and contain excerpts from the earliest reports describing these fish and waters which they inhabit as well as discussion on distribution and classification of Cutthroat Trout, behaviour, appearance, meristic characteristics, hybridization, evolution, and prehistoric distribution. The remaining 13 chapters deal with the various distinct forms of Cutthroat Trout and their distribution. This is where the book shines. Whether it is a view of the surrounding topography, pristine waters, a turbid reservoir, or description of an event such as trout rising for flies or holding their position beneath some overhanging bushes, the author paints such a picturesque setting that the reader savours the event.

The story of the Cutthroat Trout seems typical to that of other salmonids (e.g. the Atlantic Salmon and Brook Trout in the east) — over exploitation particularly by early settlers, and a large reduction in their distribution. Their extirpation from much of their natural distribution is primarily due to: (1) the deterioration of their habitat through irrigation projects and excessive grazing of streambank vegetation by cattle causing streambank erosion and loss of shading and (2) the inability of Cutthroat Trout, in general, to compete with stocked species — Rainbow Trout, Brown Trout, and Brook Trout. Further stress has been put on their populations by hybridization with Rainbow Trout and with non-native cutthroats. With the ever-increasing demand for water for cities and irrigation, a pretty picture is not painted for the cutthroat. However, a ray of hope is cast for the cutthroat since certain fisheries programs are taking steps to preserve or enhance present native stocks.

Although the book is more applicable to the west coast, it should be required reading for all those involved with fisheries management. The story of the cutthroat is in many respects similar to that of other fish species. For example, in southern Ontario the Brook Trout is extirpated in most of its native range due to habitat degradation, primarily because removal of stream side vegetation (which provided shading) has allowed water temperatures to increase above their maximum level of tolerance and because of siltation of spawning areas. Also, the inability of the Cutthroat Trout to compete with exotic trout and problems with hybridization raise several questions concerning stocking programs. In particular, what influence is the planting of lake-run salmonids having on the native fishery in streams flowing into the Great Lakes; and what influence is the planting of Splake, a cross between a Lake Trout and a Brook Trout, having on the genetic pool of these two species?

One cannot help but admire the Cutthroat Trout. This fish not only survives, but thrives under some very adverse conditions. For example, specimens 15 inches in length are found in small streams only 1½ to 8 inches deep, with some of these streams turning into intermittent pools during periods of no flow in late summer and having temperatures in excess of 26° C. It is evident that the author feels a great love for this fish and I must congratulate Patrick Trottier for a well-written book. I hope this book meets his goal of hastening awareness for the plight of the Cutthroat Trout and becomes the basis for action, so that the Cutthroat Trout both survives and increases in abundance in its native range.

GLEN BIRD

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One Man's Owl

By Bernd Heinrich. 1987. Princeton University Press, Princeton. x + 224 pp., illus. U.S.$19.50.

This is a gem of a book with many fine facets. It will be enjoyed by several groups of people — bird watchers (for whom it will answer many questions and lay to rest some myths), ornithologists, nature lovers, conservationists, and those who enjoy a really well-written book.

It is not in the "how I lived with a wild animal" genre. It is a scientific and affectionate look at a predator, a Great Horned Owl. The author found an owlet barely alive, buried under snow after a storm. For the next three years the owl lived around the Heinrich summer camp in the Maine woods, unfettered for much of the time. Whilst the scientist in him prevails, Dr. Heinrich admits to another deeper, fundamental motive which was "less lofty":

> "Quite simply I had an attack of what Edward O. Wilson calls 'biophilia', a deeply rooted affliction of many of us . . . It is the desire to gain intimacy by seeing, feeling, smelling, touching and studying the natural world." (p. 14).

Heinrich studied the bird closely, particularly its predation behaviour and mobbing by other birds. There are interesting and unexpected details about owls, such as how often and how far this owl *walked*. Waterfowl apart, one thinks of birds as flyers and perchers. Another surprise is the vast amount of food the owl could consume in a day. A typical meal consisted of a mouse, half a rabbit, a warbler, and a ruffed grouse. The diet range is extensive: crustaceans, frogs, insects, and home-made bread; but not toads, bees, nor commercial bread. Squirrels are preferred food. Owls cache food and defend the cache vigorously, which probably explains some of the "unprovoked" attacks on humans.

It is not only his detailed account of the day to day life of a Great Horned Owl but the philosophical observations on the interconnected framework of nature and its preservation which make this such a fascinating book.

> "Owlhood is not likely to be served by ministering to an owl. Helping an owl affects one owl, and that is all. One can help more owls by buying an acre of forest and keeping it wild than by preserving all of those who run afoul with fate, or with civilization. But you do not see the former, or at least you cannot touch them and point your finger and say 'Yes, I helped this owl'. The unseen, statistical owls are all too easily neglected." (p. 13).

Dr. Heinrich is an entomologist who has extended his research well beyond his original discipline into ethology and physiology, in particular, energetics. He chose to move away from the high pressure institutes of pure research to the relative tranquillity of the University of Vermont. He has written another absorbing book called *In a Patch of Fireweed* (Harvard University Press, 1984) which describes his early life and involvement with natural history as well as presenting essays speculating on the larger issues raised by his research: where does the knowledge gained from his experiments fit into the larger evolutionary picture?

One Man's Owl is printed on high quality paper which enhances the author's excellent drawings, and there is only one printer's error to report. There is an extensive bibliography and two appendices give the scientific conclusions of the study.

As Dr. Heinrich points out, there are over 6000 research works on owls, of which more than 1000 are specifically about Great Horned Owls. This one must surely rank among the best.

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Toklat: The Story of an Alaskan Grizzly Bear

By Elma and Alfred Milotte. 1987. Alaska Northwest Publishing Company, Edmonds, Washington. 114 pp., illus. U.S.$9.95; $12.95 in Canada.

Ever wonder what it's really like in the far north? Is it always cold and white with snow? What does Alaska look like, feel like and is there life in the tundra of the north? In an evening's reading for the adult and several bedtime story adventures for the children, Elma and Alfred Milotte have produced a book that will make you feel you are observing Alaskan wilderness from your front porch.

In the Toklat River Valley at the foothills of Mt. McKinley, the landscape is visualized by the luminous moon color of the winter night, giving way to the morning glow tinting the valley and hills a pale-greenish color, while the spring signals its arrival with horizontal streaks of pink and golden yellow fringed grey-purple clouds. You'll experience a summer storm with the Dall sheep and see the results of the jewellike raindrops on the tall lupines, reflecting a distorted replica of the sky. The storms, the earthquakes, and the changing panorama of color in the north all have an effect on the animals.

Simply titled *Toklat: The Story of an Alaskan Grizzly Bear*, this book offers a plethora of information on the natural habitats and habits of numerous animals and birds. The wolves, coyotes, caribou, moose, sheep, porcupines, beavers, and even the small ground squirrels play major roles in this story. Above ground, the gulls, wheatears and ptarmigans scream their warning of impending dangers as they go about their business. The Arctic Terns are introduced as the "greatest sun worshippers" who come to the Toklat Valley to nest. *Toklat* is the name given for a mother grizzly. She and her three cubs have numerous adventures with the animals and birds as they wander about their one hundred square mile backyard. As with most nature stories, man's cruel interference is apparent when Kluane, an old, bullet wounded grizzly, enters the story.

As the animals meander through the blue shadows of the Alaskan tundra the reader is drawn to the land of contrasts with the jagged peaks of the Alaskan Range and the valley's smooth contours. The clusters of willow, dwarf birch, and spruce are set in a back drop of color from numerous flowering plants. The blueberry, buffaloberry, and cranberry bushes are sought after by the animals. The wild pea vine, saxifrage, lupine, and fleabane interspersed with the white cotton grass, show their individual colors of yellows, pinks, purples, and blues. "Others, tiny and delicate showed their loveliness only to the nudging of an inquisitive breeze". And in the winter, "vast undulating snow blankets cover the river and the grassy tussocks of the tundra". Such descriptive writing is prevalent throughout the book making the reader feel the land, smell the beauty, and ponder its nature.

Toklat and her cubs, as the main characters in the story, will delight children as well as teach them the natural rhythms of the animal life in the far north. There is no fantastical drama in the book, only the excitement of true nature. The illustrations of the animals by Laura Dassow coincide beautifully with their narrative.

Easy and fun to read, this book will see readers return for second or third readings, if for no other reason than to indulge in the natural charm of arctic wilderness.

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Wild Furbearer Management and Conservation in North America

Edited by Milan Novak, James A. Baker, Martyn E. Obbard, and Bruce Malloch. 1987. Ontario Ministry of Natural Resources and Ontario Trappers Association, Toronto and North Bay. xviii + 1150 pp., illus.

This 1150-page tome with 8 sections, 71 chapters, and some 100 authors will be an irreplaceable reference for years to come. I doubt that many will read it page by page but its up-to-date, all-inclusive manner and the authoritative authors assembled to compile the data mean that it can be recommended as *the* primary source, whether you are interested in furbearer ecology, harvest economics, trapping technology, or conservation and management. Thirty species or groups of species are covered in a manner that emphasizes conservation, management, and sustainable use but that also delves into the fur trapping controversy and the needs for both research and education. In general, the treatment is very evenly balanced and I could think of nothing related to furbearers that is not adequately covered.

The initial section includes four chapters on prehistory, history, and current aspects of trapping, management, and legislation. The second section of six chapters continues this theme with discussions of the recent, current, and future directions of fur harvests, including analyses of the reasons people trap (more often for food and lifestyle than for pelt values) and educational needs. It is interesting that only 10% of the North America's half million trappers are native peoples. The third section, on management principles and techniques, provides 12 chapters of more technical information including predator control and habitat research, as well as chemical, radiological, and microscopic techniques.

The fourth section was, to me, the most important section in the book. Its 30 chapters provide, in 10 to 32 pages each, a detailed and up-to-date natural history of each species (or group) of fur species under the headings of description, distribution, life history, ecology, foods, population and range, behavior, and management. I found the accounts of those species for which I have personal research experience to be well-written, up-to-date, and comprehensive and this appears to be generally true of all accounts. Being a North American production, some groups, such as neotropical felids (one chapter), were less well-covered than others (i.e., Novak's opus on the beaver or the five chapters on different foxes). However, in all cases the references are less comprehensive than the text.

The next three sections (12 chapters), on the industry, on trapping or pelt preparation techniques, and on disease or toxic problems, were of lesser interest to me and probably to most naturalists. The technical aspects of pelt preparation would interest museum workers. It is a sign of our times that toxic substance impacts are becoming a concern in our northern wilderness species. It is also interesting that although techniques such as snares, leghold, and body traps are at least 25 000 years old, only recently has there been sufficient public pressure to create an interest in research on more humane yet still economic trapping methods. The chapter on harvest methods, by species, also gives insights into habitat and behavior. It is noted, in Chapter 64, that most furbearers are enjoying population peaks after recovery from turn of the century overharvesting. This is in spite of apparent large increases in harvests in recent years.

The final section, of seven chapters, discusses management of furbearers in the various regions of Canada and the United States. In general, it is an optimistic section, indicating increases in populations and harvests over the past 20 years. Emphasis is placed on the need for both public and trapper education, for more research, more management personnel, and, of course, for more funding. The anti-fur lobby is generally depicted as the major problem of the time.

The authors and editors are to be highly commended. Special congratulations are due to the senior editor, Milan Novak, who also contributed four chapters. The book is well organized, well illustrated, and of quality production. It is a classic at a bargain price which should be a constant reference tool for anyone interested in wild furbearers.

WILSON EEDY

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Spider: The Story of a Predator and Its Prey

By Dick Jones. 1986. Facts on File, New York. 64 pp., illus. U.S.$12.95.

There is nothing quite like enlarged colour photographs of such lowly creatures as spiders to demonstrate the beauty, exquisite detail, and the strangeness of these beasts. Although this book is geared towards young adults, I think that almost anybody could enjoy leafing through it to admire the splendid pictures and many might be inclined to learn something about these animals by reading the text. It is well written and very readable.

The usual subjects that one might expect in such a book are here. There are discussions of different kinds of spiders, their biology, predatory behaviour, anatomy, web constructions, and so forth. The author, Jones, has also included some very interesting tidbits on spiders in mythology, archeology, and medicine. The distress of "Little Miss Muffet", for instance, is related to the fact that her father, a 16th century physician, prescribed the eating of spiders for its presumed beneficial effects.

Although this book was originally published in Great Britain, the pictures and information pertain equally well to this continent. It is a nice looking book. The format is large, 9 by 12 inches, but several of the photographs are unnecessarily spread across two facing pages. The crease down the middle spoils the picture. The editing has been sloppy allowing for several typographical errors and, in one place, garbled text. A useful index is provided.

I am a little puzzled as to why Facts on File has seen fit to publish another book on spiders when they have a superb book out: *Spiders of the World* by Rod and Ken Preston-Mafham, 1984. Both spider books cover the same territory but *Spiders of the World* is far more thorough and is the sort of book that one might want to refer to time and time again. In contrast, the book under review is more like a good Life Magazine article to be savoured once and then put aside. However, the book I favour does cost more than twice as much.

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The Loon — Voice of the Wilderness

By Joan Dunning. 1986. Yankee Publishing, Dublin, New Hampshire. 143 pp., illus. U.S.$16.95.

There must be many books on this quintessential bird of North American forest lakes. I enjoyed Joan Dunning's for its text, which tells a good and complete story of the loon's life cycle through the year from salt-to freshwater and back; for its many attractive black-and-white illustrations and imaginative water colours which recapture the spirit of the bird and of the northwoods; and for its discussion of what can be done to conserve loons in cottage country. She believes that permanent human habitation of lake borders has increased the number of predators such as raccoons. Other hazards are, of course, motor boats which leave only quiet backwaters for loon nesting; these can be protected. Fluctuating lake levels caused by woods operations with dams can also spoil nesting, but can be countered by provision of rafts. Constructed of a square of cedar posts and a wire mesh base covered with turf, these nesting rafts are moored with cement blocks and enough slack line to allow for the water rise and fall. The book has appendices on voice, nesting and environmental threats, and a good bibliography but no index.

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Under Alaskan Seas: The Shallow Water Marine Invertebrates

By Lou and Nancy Barr. 1983. Alaska Northwest, Anchorage. 210 pp., illus. U.S.$14.95.

The authors' stated intentions were to provide for the layman, an identification guide to common marine macroinvertebrates of Alaska apt to be encountered intertidally or in shallow water to depths of approximately 20 fathoms. A brief introduction is followed by a photographic identification section containing 241 colour photographs of living organisms taken *in situ*. The photographs have bold numbers which correspond to subsequent numbered descriptions and life history information which comprise the bulk of the book. Representatives of 14 phyla are included; each phylum has a brief description and is often accompanied by a simple line drawing illustrating anatomical features. The book concludes with a glossary, a selected bibliography and a single index containing both common and scientific names.

I found the phylogenetic arrangement of the book convenient. The underwater photographs are stunning; only a few lost their resolution in printing. The authors' comments on colour variants, various aspects of life history and distribution are helpful and demonstrate the authors' expertise. I appreciated the authors' simple statement that not all species have common names and their integrity in not generating them for all entries in the book.

The book is not without shortcomings. Many of the photographs, although beautiful, are not sufficient for species identification. However, the authors make no such claim, and even warn the novice that identifications of many invertebrates will require the efforts of experts. Also, many common species likely to be encountered in the shallow waters of Alaska were omitted.

An exhaustive manual including only the common species of a geographic area spanning 20 degrees of latitude and the wide diversity of habitats within Alaska would certainly be unwieldy; however, I would still appreciate a slight expansion of the coverage, particularly with mollusks, shrimps and crabs. For instance, many common clams, such as the Pink-necked Clam (*Spisula polynyma*), nut clams (*Nuculana* spp.), *Yoldia* spp., Horse Clam (*Tresus capax*), and Razor Clam (*Siliqua patula*), were not included.

The book by Barr and Barr has filled an open niche. Alaskan biologists had previously been forced to use manuals written for British Columbia or the lower west coast whose species coverage only partially included Alaska. A newer manual covering Alaskan marine fauna (Kessler 1985) is also available and is complementary to the coverage of the Barrs' book. Kessler's book includes 127 fish species and 228 invertebrate species, all of which are photographed in colour in posed positions to display identification characters. The colour photographs are supplemented with many useful figures. Kessler's manual does not include intertidal species and is most useful for the eastern Bering Sea and the waters around the Alaska Peninsula and Kodiak; the Barrs' book is concerned more with intertidal and shallow water organisms, principally of southeastern Alaska.

The authors have accomplished their goals with this simple but elegant, pocket-sized handbook. I have used the book as a supplement in my invertebrate zoology and marine ecology courses. The book is a bargain. It should be on the bookshelf of every Alaskan who ventures to the sea and every naturalist who plans to visit Alaska.

Nowhere in the text is information provided about the authors. The husband-and-wife team have been naturalists in Alaska for approximately 25 years, working mainly as marine biologists and/or research divers for the U.S. National Marine Fishery Service, and most recently as commercial fisherman (Leu) and research librarian (Nancy) in southeastern Alaska.

Kessler, Doyne W. 1985. Alaska's saltwater fishes and other sea life. Alaska Northwest Publishing Company, Anchorage, Alaska. 358 pp., 370 photographs. U.S. $19.95.

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Raptor Conservation in the Next 50 Years

Edited by Stanley E. Senner, Clayton M. White, and Jimmie R. Parrish. 1986. Proceedings of a symposium, 14 October 1984. Raptor Research Reports No. 5. Raptor Research Foundation, Provo, Utah. 87 pp., illus. U.S.$4.50.

This book is a volume composed of nine invited papers with an introduction by Mark Fuller and a synthesis by Dean Amadon. The symposium was organized as part of a year-long series of events sponsored by the Hawk Mountain Sanctuary Association to celebrate the silver anniversary of the founding of the sanctuary.

The book is an interesting and informative collection of papers discussing worldwide raptor conservation issues. Ian Newton, well known for his superb work on population ecology of raptors, sets the scene with a discussion of the status of raptors in the twentieth century and the causes for their decline. This is counterbalanced by a most stimulating and encouraging look at raptor conservation in Israel, showing clearly what can be achieved, particularly in terms of public education, if both time and a little money are expended. The paper by Yossi Leshem is also favourably illustrated by several photographs of raptor watching sites in Israel and also includes a reduced copy of a delightful comic cartoon poster highlighting "Eilat — a Birdwatchers Paradise", devoted to public education.

The inclusion of a paper providing an overview of the past 50 years of raptor banding in Canada and the United States seems to add little to the symposium, as did the paper by John Haugh on raptor migration. The latter paper in particular would have been better placed in a conference devoted to that topic. Here, the author did not attempt to correlate migration requirements with the need for raptor habitat, the geography of the landscape or food supply, particularly with regard to third world countries to which many raptors migrate and spend the winter. This topic is, fortunately, expertly covered by other papers in the volume. Only two papers effectively address the topic of land management for raptors in the next 50 years, arguably the most important topic facing raptor conservation.

For those readers who need to understand the complex questions and issues surrounding the plight of the Californian Condor, a paper devoted to the condor program is, in itself, worth the price of the book. Subsequent to the issue of the proceedings of the conference, it is now known that all remaining wild condors have been taken into captivity, but this does in no way detract from the contents of the paper. For those students of raptor conservation who are pessimistic about the conservation of raptor numbers in the wild, the topic of reintroduction is clearly and succinctly summarized by Tom Cade. Numerous examples of successful introductions or reintroductions are provided, including the return of the Peregrine Falcon to North America and to Germany.

Overall, the book is an excellent volume and should be considered as required reading for both professional biologists and amateur ornithologists interested in conservation, and those that should be. It is unfortunate that the panel discussion which followed the presentations of the symposium papers was not recorded in the proceedings, as this would have added much to the presentation. It is also regrettable that it took almost four years for the volume to reach the bookshelves.

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Studies of Mascarene Island Birds

Edited by A. W. Diamond. 1987. Cambridge University Press, Cambridge, New York. vi + 458 pp., illus.

Studies of Mascarene Island Birds is the result of a British Ornithological Union expedition in 1974. The 13 years it has taken to produce this work is, I'm sure, a reflection on the lack of funding from which such enterprises suffer. Fortunately, the book is not 13 years out of date. Changes and additional data from the early to mid 1980s have been incorporated where available.

The Mascarenes are a group of Indian Ocean islands which include Mauritius, Reunion, and Rodrigues. As with most isolated islands they are, or at least were, populated with many unique species of animals. Typically, they survived in a state of balanced harmony, until that great age of human exploration, which began in earnest in the 1600s. The impact of humans, their attendant companions; rats, cats, pigs, goats, and so on, and their efforts to "improve" on nature have taken their toll.

This book, which more closely resembles a series of scientific papers than a narrative book, examines the natural history of the Mascarene endemics. To do this the authors have scoured the historical records to estimate the status prior to the arrival of Europeans. In most cases this is very difficult as many of the early explorers were poorly educated, especially in scientific methods. Information is often confusing, generally incomplete, and can never be used with certainty. The authors have had to become historical sleuths.

Their own work is more precise but perhaps not a great deal more accurate. They had to research vastly reduced populations, scattered in difficult-to-reach remnants of habitat, using limited resources. Despite these drawbacks they have given us a clearer understanding of the Mascarene endemics. The eighteen surviving native birds are described in as great a detail as possible and other endangered animals are not ignored.

The authors make great efforts to estimate the current breeding populations of the native birds. This is accompanied by as full a description of each bird's ecology as possible, with special attention paid to breeding behavior and requirements. The impact of human interference is carefully considered. The overtone to this text is the understanding required to save the species. While reading, I frequently developed ideas that I felt sure would help (like the provision of nestboxes and supplemental feeding) but sadly, these obvious concepts are all in operation and have not proved to be the looked-for success. Current hopes are being pinned on captive breeding programs.*

The main text is supported by maps, charts and drawings as required by the scientific text. There is no art work per se and this is a sad omission as many, such as the Echo Parakeet and Mauritius Kestrel, are attractive birds. Others like the Mauritius Bulbul are less colourful but I'm sure readers would enjoy illustrations of all of these unfamiliar species. The text is not much help in this regard either as descriptions are limited or non-existent. I would like to have seen some general photographs of the islands themselves as well.

In addition to the basic, island by island, species by species, description of the history and ecology of the remaining native birds, there are a number of other useful chapters. There is a detailed ecological history which pays particular attention to extinctions and the introduction of alien vertebrates. The fossil record adds a novel perspective and a reminder that extinction is a natural process too. The chapter on vocalizations is illustrated with sonagrams but these are lost on me. I have still not managed to convert these fuzzy blotches into sounds in my mind. Fortunately the text contains good descriptions of the songs and the field work required to obtain them. As benefits a scholarly work, there are tables of original data. Finally, there must be close to a thousand references, ample for any serious researcher.

This book will be valuable to anyone involved in the ecological research of endangered species. Visitors to the Mascarenes may find it useful, depending on their interests, as the book is by scientists for scientists. The lay reader, wanting more light-hearted fare would do better with *Golden Bats and Pink Pigeons* by G. Durrell (1977. Collins, London) Durrell is successfully involved in the captive breeding program at his Jersey Wildlife Preservation Trust, where he uses as his emblem the quintessential symbol of extinction, a Dodo, the most famous Mascarene bird.

Footnote

*(Concern has recently been expressed over the appearance of physical defects in Mauritian Pink Pigeons bred in captivity, and the possibility that this is a result of inbreeding. See Cooper et al. *Ibis* 130: 57-64).

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BOTANY

The Tumbleweed Gourmet: Cooking with Wild Southwestern Plants

By Carolyn J. Neithammet. 1987. University of Arizona Press, Tucson. 220 pp., 173 recipes, illus. U.S.$20.00.

I enjoyed preparing a review on *The Tumbleweed Gourmet* for three reasons. The first, because I spend five to six months each year in our winter home south of Tucson, in the tumbleweed desert environment. While there I spend two days a week hiking in the Sonoran desert and have become familiar with many of the plants of the area. And thirdly, I write a cooking column for the family weekly newspaper back in Ontario, and have a voracious appetite for recipe books.

In *The Tumbleweed Gourmet*, more than 170 original recipes prove that abundant delicious foods lie literally at the doorsteps of many desert dwellers. For those living outside the southwest, or who don't wish to pick the flowers, the new University of Arizona Press book suggests alternate ingredients and includes a list of mail order distributors.

I enjoyed reading this very informative book, and found the sketches of each plant very clear and helpful for identification. For this reason alone the book is invaluable. Taking a hike in the desert, or a walk in the backyard of our townhouse, will never be the same again.

In the countryside around St. Marys, Ontario, I was amazed at how many edible plants could be found. Cattails, wild mustard, sunflowers, and squash blossoms are a few northeast plants also featured in *The Tumblewood Gourmet*.

The recipes ranging from Tumbleweed Fritatos to Sunflower Rolls have all been adapted to modern cooking and come with a history of the plant and lively anecdotes for easy reading pleasure. The author also warns about gathering wild plants near roadways because they may contain toxins from car exhaust; and near agriculture fields because they may have been sprayed with pesticides.

Cooking with wild plants isn't for everyone, but anyone who is a nature lover and especially for those interested in the southwest, this book is a must. As a gift to someone you know, who collects recipe books, it is a steal at $20.00.

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The Rare Plants of the Mingan Archipelago

By Line Coullard and collaborators. 1986. Canadian Government Publishing Centre, Supply and Services Canada, Ottawa. 95 pp., illus. $10.95 in Canada; $13.15 elsewhere.

Many visitors to the Mingan Islands, one of Canada's smaller National Parks, will find this colourful little book a delightful memento of a tour to these islands which lie on the north side of the Gulf of St. Lawrence. The authors describe the islands, their geography, the harsh climate, geology, habitats in which rare plants grow, and give a quick view of the flora and botanical history of the area in quite simple language.

The Mingan flora comprises 452 species of which 39 are considered to have unusual range characteristics. Five categories of plants rare on the islands are considered: (1) Species confined to the Gulf of St. Lawrence (endemic plants); (2) Species from the west (cordilleran plants); (3) Arctic or arctic-alpine species; (4) Quebec boreal species; and (5) Species at the northern limit of their range. These categories are briefly described and sketch maps of North America that depict the different kinds of distribution accompany each description. From each of these groups a selection of representatives has been taken, a total of twenty-four. These were painted in water colours by artist Denise Pelletier from plants in their Mingan habitat. On the page opposite each painting the English, French and Latin names are given together with the plant family to which the species belongs and an indication of the size to which the plant grows. This is followed by a paragraph on each of: origin of Latin name, the plant and its habitat, and range.

This simple book may wet the appetite of some to delve more deeply into botany. As a start, nineteen references for further study are provided. It is unfortunate, however, in a book in which there are so few scientific names, that two of these were misspelled.

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Colorado Flora: Western Slope

By William A. Weber. 1987. Colorado Associated University Press, Boulder. 530 pp., illus. U.S.$19.50.

This book is a companion to, and is written in the same format of expanded keys as Professor Weber's *Rocky Mountain Flora* that was published in its fifth edition in 1976. *Colorado Flora: Western Slope* treats some 2150 species that are known to occur in Colorado west of the Continental Divide, roughly the western two-fifths of the State of Colorado.

Users will find differences between the two floras which, for some, may be an inconvenience. In the earlier work, the ferns and fern allies and gymnosperms were at the beginning of the book, followed by the families of dicots in alphabetical sequence, and then the families of monocots in alphabetical sequence. In the latter work, the ferns and fern allies and gymnosperms are again at the beginning, but the families of angiosperms, monocots and dicots, are mixed together in alphabetical order. Thus, for example, the grasses (Poaceae/Gramineae) lie between the plantain family (Plantaginaceae) and the phlox family (Polemoniaceae), and the sedges (Cyperaceae) lie between the dodders (Cuscutaceae) and lady's slippers (Cypripediaceae) which is in turn followed by the teasels (Dipsacaceae). Another innovation which will take some getting used to is the method used in the two indexes. Page numbers are not used, but rather families are assigned three-letter codes or acronyms which are used to locate the desired place in the book. Thus when searching for wallflower (*Erysimum*) one is given the reference BRA (= Brassicaceae) so that one can find the plant in the section on Brassicaceae which in turn has its genera in alphabetical sequence. Species are not listed in the generic index, but only genera, which may be found in the same manner as the common names. There is thus a disadvantage in not knowing readily what species occur in a particular genus in western Colorado, particularly in the larger genera. Some users may feel too that the author has been over zealous in taking up the splitting of certain genera, e.g. the genus *Dichanthelium* split from *Panicum*, and the separating of *Comastoma, Chondrophylla, Gentianella, Gentianodes, Gentianopsis,* and *Pneumonanthe* from *Gentiana*, but that is his choice.

The descriptive information adjacent to a particular species is usually limited, but more information is always available by referring back through the keys. Habitat data is provided as well as an indication of where it might be found in the area of the flora, if restricted, but there is no overall distributional information given for each species. Dates of publication of genera are given. For most genera and species an interpretation is given, e.g. *Draba* [Gr. *drabe*, applied by Dioscorides to some cress] *porsildii* [for A. E. Porsild, contemporary Danish-Canadian botanist]. Readers will find the information provided with the family and generic descriptions to be fascinating: an example in Solonaceae, the Nightshade Family — "The drug, atropine, used for dilating eyes, comes from *Atropa belladonna*, and in Delibes' grand opera, *Lakme*, the heroine commits suicide by eating the flower of *Brugmansia*".

Introductory materials include a foreword written by E. Gordon Gee, President, University of Colorado, acknowledgements, a preface, and an introduction which includes such information as: Scope of the Book, Physical Geography, Floristic Zones, Plant Geography, The Altai Connection, Families Treated in This Book, Some Floristic Statistics, Generic Concept, Common Names, Pronunciation, Miscellaneous Notes, and Eponymy – Botanists honored in Colorado Plant Names. A glossary of botanical terms may be found just prior to the index of common names.

Colorado Flora: Western Slope is the culmination of many years of study of the Colorado flora by Professor Weber and will most certainly be welcomed by botanists, naturalists, and students as well as those in related sciences, not only in Colorado, but in the adjacent states as well.

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Wildflowers: Nature Stories for Children.

By G. Keleher. 1985. Hyperion Press, Winnipeg. 40 pp., illus. $4.95.

and

Trees: Nature Stories for Children.

By C. Nelson. 1986. Hyperion Press, Winnipeg. 40pp., illus. $4.95.

Hyperion Press has issued a dozen or more offerings in its Canadian Album Series of children's natural history books. They combine a large (20 x 26 cm) page of text with a facing full-page sketch of the feature being discussed. The picture is to be coloured in by the young readers. In *Wildflowers* and *Trees* the text is offered in two parts. The first describes an adventure or discussion experienced by one or more children that includes the plant in question. These often include an adult telling the children about human applications of the species. The second portion of text, in less conspicuous type, offers more technical information, including the scientific name, identification features, range, etc. Colouring instructions complete the writing.

The idea is a good one — provide a hands-on item (the colouring book) that instructs while it entertains (the story) and offers more information (the "technical" write-up) for the keeners to carry on with. In reality, however, I wonder if this is achieved.

The different vehicles of communication (the story, the picture, the write-up) require different levels of reading expertise and maturity. I wonder if a child old enough to understand such terms as cross-pollination, compound leaves, and elongated ovaries would still be interested in colouring them? Conversely, would a child attracted to a colouring book be able to add to their appreciation and knowledge of the wildflower or tree as a result of the text?

The pictures are somewhat limiting, too. While the wildflowers are attractive enough, they are stylized. The trees, on the other hand, are laid out in a very basic fashion. I doubt very much that most children would be able to see anything distinctive in the sketches of Manitoba Maple, pine, cherry, or White Elm, for example.

I fear that in trying to get too much across to too broad a spectrum of readers the series misses them all to some degree. It is an interesting concept, nonetheless, and might well succeed with a tighter control on the verbiage and perhaps a little bit of "field testing".

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Flora of the British Isles (Third Edition)

By A. R. Clapham, T. G. Tutin, and D. M. Moore. 1987. Cambridge University Press, Cambridge. 688 pp., illus. U.S. $150.

In consideration of the long history of accidental and intentional introduction of plants from Great Britain and western Europe into Canada and the large number of species with ranges encompassing both areas, botanists here are well advised to have access to at least some of the major European floras. The five-volume *Flora Europaea* produced between 1964 and 1980 is an excellent if expensive choice. The newly published *Flora of the British Isles* (third edition) is a less expensive and very reasonable option.

The third edition is the latest in a long line of British floras that extend back to John Ray's *Plantarum Angliae* in 1670. When first published in 1952, the *Flora of the British Isles* provided a long-awaited modern treatment. To quote from the preface, it is intended ". . . not merely to assist in the identification of native species but also to provide . . . information of a general use to those interested in their ecology, geographical distribution, evolutionary history, agricultural significance, etc." The authors, all distinguished British scientists, have aimed the book at serious amateurs, at students, and at taxonomic generalists. By all appearances, they know their audience well; this is no "wildflowers of Britain"!

The third edition follows the basic course set out in the first (1952) and second (1962) editions. The advances in botany since the earlier editions are reflected in updated taxonomy, more ecological information and more frequent cytological data. It follows *Flora Europaea* as the standard for nomenclature wherever possible.

Following an interesting outline of the history of British floras that puts this effort into perspective, the preface identifies an impressive list of taxonomic specialists who contributed to the book. A fine synopsis of the classification of the flora, an artificial key to the families treated in the text, and a list of abbreviations used in the species accounts concludes this concise and useful introduction.

The *Flora* follows a modernized version of the Bentham and Hooker model (*viz.*, pteridophytes, gymnosperms, then angiosperms). Within each class, families and genera are arranged from the most primative to the most advanced. The heart of the work, the species accounts, is placed within this and is excellent. Following a technical discussion of each family a simplified key identifies the genera. A comparable discussion of each genus (including a statement on the worldwide size of the group) is followed by a concisely-worded and clearly-arranged dichotomous key. Each species in this unusually descriptive key is sequentially numbered as a reference to its place in the accounts. Working randomly with the book I found these keys to be easy to use and as unequivocal as possible.

The name of each species, highlighted in bold type for easier reading, initiates the account. Synonyms (rather fewer in many cases than I would have wished) are listed next, followed by a detailed technical description. In any flora the species descriptions are critically important. In *Flora of the British Isles* they are terrific and include a great deal of precise, valuable information in remarkably few words. Although virtually every one was written by only one of the authors, they are quite uniform in style and detail. As with *Gray's Manual of Botany* (eighth edition), particularly important identification features are singled out by the use of italics. This is very helpful.

Chromosome numbers are offered as is the Raunkiaer life form classification. The native status of the taxon in the British Isles is clarified, and its habitat and range (local and worldwide) are succinctly described. The discussion of subspecific taxa (also labelled in bolder type) follows. A large number of species and hybrids that are marginally part of the flora by virtue of their being infrequent and/or local escapes are described in smaller type but are not included in the keys. These constitute a valuable supplement to the data on the well-established plants of the British Isles.

Over 80 pen-and-ink sketches are scattered through the text, representing typical species of large groups or providing illustrations of various morphological features. The sketches are referred to in the appropriate citation in the glossary, increasing the value of both contributions significantly. This excellent glossary would have been better yet had sketch references been to page numbers rather than figure numbers; the reader is left to thumb though many pages of text before finding the desired illustration — an unnecessary annoyance.

The index looks very good (*another* major flora that includes authorities with the species' names — wonderful!) but is not without flaws. I found several omissions soon after opening the book, the most striking being the failure to list the names for genera *Typha* and *Juncus*. These look like computer-generated errors and are not significant in their own right (they follow family names that are very similar and all species in the genera are listed). The omission of a species in a complex genus (*Hieracium exotericum*) does little to restore one's confidence in the index, however. How many other "glitches" are there like these?

The book is solidly bound with a glued and stitched binding and is printed on good quality, durable paper, which enhances the readability of the small but clear type. The lay-out is plain, practical and very effective.

To sit down and read a book like this would be daunting indeed and I did not read all of the species accounts for this review. I read many, however, and I worked with the book for several months in the course of regular botanical studies. Even with *Flora Europaea* readily available, I found this book to be a tremendous help by providing an up-to-date and credible reference to many of the cosmopolitan plants and introductions of European origin that we encounter in eastern Canada. This book is a remarkable achievement and is an excellent investment for field and herbarium botanists on both sides of the Atlantic. Now if someone would just do this with *Gray's Manual* . . . !

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The Mushroom Manual

By Lorentz C. Pearson. 1987. Naturegraph Publishers, Happy Camp, California. 224 pp., illus. U.S. $8.95.

A well-written handbook for the beginner, *The Mushroom Manual* concentrates at first on four easily recognized, edible mushrooms, called "the foolproof four". Another chapter entitled "the fatal five" discusses five readily recognized poisonous mushrooms, their toxins, the effect of toxins on the human body, and how to recognize the major groups of poisonous mushrooms. Dr. Pearson's philosophy — learn a few and learn them well before getting involved with the hundreds of different species in the woods — is a good approach for the beginning student.

Subsequent chapters describe additional rather distinctive edible and poisonous species and present some hints on tasting mushrooms and on preparing them for the table. The final 100 pages of the book are divided among dichotomous or multiple-choice "keys" for identification of several hundred different mushrooms; a synopsis of the principal features of the major groups, i.e. families and genera; and a glossary.

The author's conservative taxonomy, which uses very generally defined genera and families, causes some problems in his circumscription of families and will perplex some students. For example, the species usually placed in *Leccinum* are referred to *Boletus*, and the definition of the family Thelophoraceae as "mostly polypore-like fungi with minute pores and dark colored spores" is quite mistaken.

The principal weakness in the manual lies in the illustrations. The colour plate depicting spore print colors for the dark spored groups is not useful due to the poor quality. Only two mushrooms are pictured in colour: the frontispiece is of *Morchella* *conica* and the cover is a beautiful photograph of *Suillus spectabilis*. There are about 150 species illustrated in black-and-white line drawings, which are not executed in great detail; thus, some of the illustrated species are not readily recognized. In figure 32 the captions A and D appear to be reversed.

Those mushroom hunters who like to compare their collections with pictures may not be satisfied with this book, simply because the drawings were not meant to be used alone but along with the text. There are a few typographical errors. One worth correcting is on page 51 where "death cap" should read "death cup". In the index the list of species of *Suillus* is missing.

In summary, this book is a good introduction to the study of mushrooms which emphasizes the "safety-first" approach to collecting, eating and identifying wild mushrooms.

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The European Garden Flora. Volume I: Pteridophyta, Gymnospermae, Angiospermae-Monocotyledons (Part I).

Edited by S. M. Walters, A. Brady, C. D. Brickell, J. Cullen, P. S. Green, J. Lewis, V. A. Matthews, D. A. Webb, P. F. Yea, and J. C. M. Alexander. 1986. Cambridge University Press, New York. xv + 430 pp., illus. U.S. $99.50.

This work is a companion piece to the *Flora Europaea* and deals with the garden and conservatory plants cultivated in Europe. Many of the included treatments are based on recent monographs. It is important to remember that this work is a flora, not a gardening encyclopedia, and so has a somewhat different emphasis. Volume I covers pteridophytes (ferns), gymnosperms (conifers), and some monocots, the major ones being the Liliaceae, Iridaceae, and Amaryllidaceae. Volume 2 (which was published in 1984) also dealt with monocots, particularly bromiliads, palms, gingers, cannas and orchids. In all, six volumes are planned.

Each entry includes the correct species name, synonyms, a description, references (including ones to good illustrations), geographical distribution, hardiness, flowering time, subspecific variants (if a species has many named cultivars only the most common are given, but reference is made to supplemental registration lists), and in some cases notes on culture. Widely grown hybrids are given the same treatment as full-fledged species. Each taxon is dealt with in a formal (for large genera) or an informal (for small genera) key. The importance of this work in stabilizing the nomenclature of horticultural plants cannot be overemphasized.

The authors have made a great effort to take into consideration the needs of the informed amateur gardener. In species names, authorities are written out in full so as not to confuse the reader with cryptic abbreviations. The same is done with journal references. Standard english place names are used instead of the vernacular ones as was done in the *Flora Europaea* (e.g. Crete not Kriti). The informal keys focus on characters which are found in only a few of the species in a particular genus, thus allowing the reader to quickly reduce the number of possible choices. A generous supply of illustrations (44 plates) and a glossary supplement the keys and descriptions. One minor quibble: the common names of families, genera, and species are nowhere given. This is a very useful reference indeed.

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Red Pines on the Ridge

By Leon E. Pavlick. 1985. Braemer Books, Victoria. 33 pp., illus. $12.95.

Red Pines on the Ridge is the first book in an "On the ridge" series by Leon Pavlick — a series designed to mesh the interpretation of natural history and simple story telling. The approach used to achieve this is an anthropomorphic one in which the Red Pine is treated in the first person and observes and comments on the various changes which occur on its ridge during its lifespan.

The book itself is short, only 33 pages, and is easily read at one sitting. It is well produced and illustrated (by Lissa Calvert) with charcoal sketches and full-colour illustrations. They greatly add to the text. The information contained in the book is factual and accurate; unfamiliar terms are explained in footnotes, and an extensive reference section is included. It is obvious that the author has a deep regard for the natural world, and his opinions of forest management practices are evident.

The author has set himself a challenging task — to both educate and entertain without one process destroying the other. The education was certainly there, but the entertainment was not sufficiently strong to hold my interest. To treat the Red Pine in the first person is an interesting literary device but one that does not quite work here. One moment we are given a bit of factual information, next we are reading of the pine tree's emotional response to the cutting of its neighbour. The sense I had was of a number of vignettes, like a wonderful group of dioramas at a museum with an accompanying audio track. It may be no coincidence that the author is a research and interpretive botanist at the Royal British Columbia Museum.

I question whether there is enough hard-core natural history to entice many naturalists. Similarly, the story-line may not be strong enough to attract those with only a peripheral interest.

The problem of *Red Pines on the Ridge* may be mostly one of a misdirected audience. I gave this book to my 11-year-old stepdaughter Joni and she really enjoyed it. She found the pictures lovely, the explanation of terms helpful, and she particularly enjoyed the use of the tree as a thinking being. So perhaps that is where this book will be a success — with a younger readership.

To entertain and to inform at the same time is a formidable task. The author is to be commended for attempting to take natural history education in a more literary direction.

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The Trees of North America

By Alan Mitchell and David More. 1987. Facts on File, New York. 208 pp., Illus. U.S. $24.95.

This is a good-looking book. It devotes two pages each to 84 groups (500 species) of North American trees. The short text describes the characteristics, propagation and range of each group, as well as details of notable individual trees and where to find them. Coverage is uneven. For instance, inhabitants of Revelstoke, British Columbia, may be interested to learn how many noteworthy trees their town harbours! The ranges for species are depicted by the two-letter abbreviations for provinces and states. Unless your knowledge of geography is better than average, it is better to use the small range maps in the appendix. Some of the english used is eccentric, which, coupled with inadequate proof reading, makes reading laborious.

It is in the illustrations, however, that the value of the book lies. The colour paintings and drawings are beautiful and very clear. Leaves, bark, flowers, fruits, and the general conformation of the species are illustrated. There is an appendix describing aspects of garden planting, and the text sometimes includes mention of commercial use, longevity, and edibility of the fruit or nuts.

It is hard to place this book in a category: its hard cover and size make it too large for a field guide, while its coverage is probably not detailed enough for a serious gardener, field naturalist, or forester.

The publishers have produced valuable dictionaries and compendiums covering a wide range of subjects. This text does not quite meet their usual standard.

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An Illustrated Flora of the University Endowment Lands

By Gerald B. Straley and R. Patrick Harrison. 1987. Privately published, Vancouver. 205 pp., illus. $15.

Very few annotated floras are available for regions of British Columbia, so this contribution on the flora of the University Endowment Lands (UEL), adjacent to the University of British Columbia in Vancouver, is a welcome addition to the Canadian botanical literature. It is a ring-bound, mimeographed production (this has enabled the authors to keep the price down) and it deals with 384 species of vascular plants that are either native or occur spontaneously in the UEL. Pictorial keys facilitate the identification of all species. A major portion of the text is devoted to comments on the status, and in some cases, additional identification pointers, for each species in the UEL.

All species treatments are accompanied by small line drawings. These drawings will certainly be helpful in the identification of UEL plants, but they will be of limited use outside of the built-up part of Vancouver. The native flora of the UEL comprises less than half of the total flora, and many similar species that occur in the adjacent forests cannot be distinguished by these drawings or keys (nor were they intended to be).

This flora has been written for the non-specialist. The majority of the potential market for this book is likely to be inhabitants of Vancouver who are interested in casual observation of the plants along the extensive trail system (41 km) within the UEL. With this in mind, the authors have minimized the number of technical terms in the keys and species treatments, and they have emphasized vegetative characters whenever possible.

The text is divided into an introductory section, the keys, species treatments (with families, genera, and species in alphabetical order), several appendices (including lists of plants that do not generally persist, plants that are expected to occur, and a checklist), a list of cited literature, and a glossary.

Every reviewer has his/her own preferences about how a particular book could have been written, and I'll mention a few substantive points that would improve future revisions. In the introduction, a fairly coarse map of the UEL is included, with all of the trails indicated. A clearer base map would be helpful. Perhaps more important than this should be the inclusion of a map of the lower mainland or southern British Columbia, putting the UEL into a regional context. Another aid to the user would be the cross-referencing of the species in the checklist (Appendix 3) with the page number on which its treatment appears in the main text. It should be noted that the keys *are* cross-referenced in this way.

In several places within the keys, the leads aren't concise enough. The user is often faced with a choice between one specific condition, such as "flowers yellow", and the general alternative "flowers not as above". Although this kind of choice is common in keys, it is better to include some kind of descriptor in the alternate lead, like "flowers white, blue, or red". The glossary on the last page of the book contains a series of concise definitions of terms that a non-botanist might not recognize.

The authors have done an admirable job in their stated aim of minimizing technical terminology. However, I did find a few additional terms that should be added to the glossary. These include, "irregular flower", "legume", and "inferior" and "superior" ovaries. Most users will probably know what legumes are, but they might not know how to separate the "legume" fruit type from a "fleshy capsule" (p. 22). On p. 35, some specialized knowledge would be required to realize that *Iris* flowers have three stamens, because of their highly modified structure.

Finally, there are quite a few spelling errors and a few production errors that crept in somewhere along the line. For example, on pp. 37-38, the illustrations for *Acer pseudoplatanus* and *A. platanoides* are switched (although they are correctly placed in the species treatments). The lead distinguishing *Coronilla varia* and *Lotus corniculatus* is muddled (p. 68 and p. 152).

Although I've outlined a number of problems, these will generally not impair the usefulness of the book. It's nice to see regional floras being prepared, and I hope that similar projects will be completed throughout Canada. This book should amply fulfil its purpose of serving as a guide to the vascular plants of the UEL, and I recommend its use by students, naturalists, residents, and visitors in the UEL area of Vancouver.

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ENVIRONMENT

Nature Conservation: The Role of Remnants of Native Vegetation

By Denis A. Saunders, Graham W. Arnold, Andrew A. Burbidge, and Angas J. M. Hopkins. 1987. Surrey Beatty and Sons, Chipping North, New South Wales, Australia. xiii + 410 pp., illus. U.S. $60 including postage.

For approximately 20 years ecologists and conservation planners have been working with the concept of island biogeography. The theory is simple: the larger an habitat island and closer it is to other similar habitats, the more species it can contain. The idea has caught the imagination of many because it provides a theoretical backing to the thrust to conserve large pieces of remnant vegetation during the ongoing rapid and worldwide destruction of natural terrestrial ecosystems with their replacement by barren agricultural and urban ecosystems.

The literature that documents this field has been growing at a steady and improving pace. To my knowledge, the majority of the work has been done by scientists in North America and Europe.

Natural Conservation: The Role of Remnants of Native Vegetation contains 52 papers from a workshop held at Busselton, Australia, in September 1985. This new and impressive book is a major compilation of work of a large number of researchers, most of them from Australia but some from New Zealand, Great Britain, and the United States.

The book contains summary papers from some of the most published researchers in the field. James Lynch does a nice job of summarizing the literature on the responses of breeding bird communities in eastern North American forest fragments. Robert Whitcomb attempts to cover the literature for "North American Forests and Grasslands" but conveniently leaves out any studies from anywhere other than the United States. However, the best of the summary papers is one by Michael B. Usher of the University of York in the United Kingdom. This paper is entitled: "Effects of Fragmentation on Communities and Populations: A Review with Applications to Wildlife Conservation." This superb piece of writing successfully covers most of the major literature in the field in a readable and lucid fashion. I intend on using this paper in the future for the instruction of advanced university students in this field.

However, the most significant aspect of the book is the plethora of papers from Australia. I have attempted to follow the literature on island biogeography in the last few years and the advanced level of research in the field in Australia comes as a complete surprise. I guess that I am more isolated in the wilds of southern Ontario than one would care to admit.

Let's try to summarize some of Australian papers. An early paper in the book is one by A. R. Main of the University of Western Australia. It outlines an approach to the management of remnants of native vegetation in the wheatbelt of southwestern Australia. It sets a familiar tone that is to follow often: advanced ecological understanding with associated field management action. One of the outstanding features of this work is the level of management sophistication attempted in these remnants. For example, a table in the paper outlines the nutrient situation following various disturbance patterns and the management responses necessary to deal with soil nutrients.

There are many papers that cover the findings of studies on specific Australian communities or species. A. Hopkins and D. Saunders of the Department of Conservation and Land Management provide details of the size and distribution of protected areas of Western Australia. They then discuss the details of ecology of the Carnaby's Cockatoo, a species that is affected by fragmentation of its habitat, and use the understanding of this species to discuss more general conservation problems. A considerable number of the papers are of this ilk, conservation managers reporting on their work in the field. The book appears to show a good level of program integration between the academic researchers and the government land managers in Western Australia.

Various other papers discuss issues such as: conservation of rare eucalyptus, the role of ecological connectors between communities, long term ecological monitoring, fire management, introduced species, nutrient cycles, various indicator species, modelling management strategies, and role of site management. None of these topics are new but the Australian findings, mostly from a semi-arid landscape, are revealing and challenging.

This book is a major contribution to the field. It must be read by all scientists and conservation managers who are attempting to understand and work within the framework of remnant ecosystems. The Australian research is now at the forefront of the world's scientific understanding of the role and management of remnant ecosystems.

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Ecology: Individuals, Populations, and Communities

By Michael Begon, John L. Harper, and Colin R. Townsend. 1986. Sinauer Associates, Inc., Sunderland, Massachusetts. 876 pp., illus.

The new and refreshing approach of this undergraduate general ecology textbook ought to be appreciated by instructors and students alike. What makes this book different is that it is organized on three levels: individual organisms, populations of organisms, and communities of populations. (This book covers the typical ecosystem topics in its section on communities since the authors believe that no ecological system can be studied in isolation of its environment.) This three tier approach builds upon itself and flows in a logical direction. It is based on the premise that the individual organism is the material upon which natural selection works with the effects and interactions of individuals accounting for the activities of populations and communities.

The authors also present the most recent hypotheses about each facet of ecology that they explore. For example, in their discussion of the mechanisms that underlie autogenic succession, they review Horn's 1981 model of tree-by-tree replacement in forest succession, and Connell and Slayter's 1977 three models of succession: facilitation, tolerance, and inhibition. Then they go on to review Noble and Slayter's 1981 classification of "vital attributes" which influence a species role in succession. These new models are more successful at explaining field data than Frederick Clement's original facilitation model. They represent the advancement that has been made in our understanding of succession.

The presentation of the ecology of organisms is unique in its in depth treatment of the life and death of modular and unitary organisms. The authors' did an admirable job of presenting the conditions and resources of an organism's environment, but I was surprised by the light treatment of soils and the absence of a significant treatment of fire — especially when one considers its role at all three tiers in most terrestrial ecosystems.

The authors do an excellent job of presenting the ecology of populations. They cover intraspecific competition, interspecific competition, predation, population dynamics, parasitism, disease, and mutalism in much greater depth than is commonly found in older general ecology textbooks. Over one-third of the pages in this book are devoted to population ecology while most texts devote only about one-tenth of their pages to these topics. This high coverage is probably a reflection of the excellent population ecology expertise of the authors. The use of mathematical models in this section is kept to a simpler level than is found in *Population Ecology* (1986) by Begon and Mortimer although both books do share many of the same examples.

Over one-fourth of this book is devoted to community ecology. The authors' cover energetics, nutrient dynamics, biomass production, community description, patterns of species diversity, community stability and structure, island biogeography and the influence of competition, predation, and disturbance on community structure. The coverage of these topics is original and well done. However, the chapter covering the description of plant communities lacked coverage of the habitat type and ecological site concepts that are in widespread use in the forests and rangelands of the western United States by ecologists and land managers. In general, the coverage of plant community classification was much lighter than that encountered in older textbooks. This is probably a reflection of the declining popularity of this field.

The emphasis of this book is on theory with little discussion of field sampling techniques, biogeography, and the major ecological crises facing the earth. However, the theory is backed up with numerous examples from all types of fields. Entomology and marine biology receive much better representation amongst the field examples than they have in the past. In addition, examples from Europe and North America are represented more equitably than one would expect. The book itself is properly bound and in hardcover. The pages have highlights from the text printed in wide margins along the edge of each page. The margins leave ample room for the reader's own notations.

The British authors of this book have made a successful presentation of the field of ecology at its present position in time. Their book will probably serve as the flagship of general ecology textbooks well into the next decade.

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Companion To A Sand County Almanac

Edited by J. Baird Calicott. 1987. University of Wisconsin Press, Madison. x + 308 pp. U.S. $22.50.

Aldo Leopold's collection of essays on nature and our species' relationship to it, *A Sand County Almanac*, was published in 1948, but it did not begin to attain cult status until the 1970s when it was adopted by the American environmental movement. At about the same time, it was also discovered by philosophers as they wrestled to define the new field of environmental ethics. One of those philosophers was Baird Calicott, the editor of this *Companion*. He was so impressed by the *Almanac* that he organized this collection of "interpretive and critical essays" to examine the historical, social, artistic, and philosophical importance of Leopold's most familiar work.

Ten authors contribute to the *Companion*. In most cases the contributions are essays that have appeared or will soon appear in other places as well. The major exceptions are the chapters by the prominent environmental philosophers Holmes Ralston, on "Duties to Ecosystems", and Callicott himself, on "The Conceptual Foundations of the Land Ethic". Other contributions range from a short biography of Leopold and a description of his retreat in the "sand counties" of Wisconsin, to excerpts from earlier drafts of the *Almanac* and from correspondence with prospective publishers. Styles vary, but most of the contributions should be accessible to the general reader.

The publisher's blurb on the dust jacket begins by saying that "Aldo Leopold's *A Sand County Almanac* is the bible of the modern American conservation movement . . .". That phrase introduces two of my main problems with the book.

First, it is oppressively American. Like maps in American textbooks that show nothing but blank space beyond the U.S. border, many of the essays seem to take it as a matter of course that nothing of importance has or will take place outside "the nation". In an unintentionally (I assume) funny passage, for example, Callicott lists, with nationalities, a number of philosophers who have been critical of Leopold's ideas — foreigners all. There is more than a bit of irony in the fact that a group of authors who argue for the extension of ethics beyond the human species seem trapped by a narrow national parochialism. Philosopher, heal thyself.

Second, many of the authors seem intent on the deification of Leopold, almost literally. There are frequent uses of the words "prophet" and "bible". John Tallmadge compares the *Almanac* to the sermons of Jesus. Wallace Stegner goes furthest off the deep end: "when this forming civilization assembles its Bible, its record of the physical and spiritual pilgrimage of the American people, the account of its stewardship in the Land of Canaan, *A Sand County Almanac* will belong in it, one of the prophetic books, the utterance of an American Isaiah". With such nonsense scattered through the book, the credibility of the rest must suffer.

I think Curt Meine gets it about right in his discussion of the "Land Ethic", the pivotal section of the *Almanac*. "While he [Leopold] is definitely erecting ethical standards in this statement, according to the criteria of integrity and stability, it seems he was more concerned with touching a broad base of human perceptions of the environment than with developing a hard-and-fast set of timeless standards". Meine concludes that "others tried to articulate a comparable philosophy of conservation during Leopold's lifetime, and many have tried since, but "The Land Ethic" remains a notable success".

There are many examples of similar calm scholarship in the *Companion*. There are excesses as well, but they can be tolerated as the result of enthusiasm for an important work. General readers might better spend their time reading or re-reading the original. Specialists in conservation or environmental ethics will benefit from reading the *Companion*, as long as they keep their critical faculties sharp.

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The Encyclopedia of Animal Ecology

Edited by Peter D. Moore. 1987. Facts on File, New York. 144 pp., illus. U.S. $24.95; $33.95 in Canada.

Peter Moore has been writing articles for *Nature* for many years, interpreting developments in ecology for a professional scientific readership. With this book he takes on a more difficult task: explaining modern ecology to a general audience. He does it very well, managing to introduce up-to-date ideas of ecology while still being accessible. The average reader will probably not realize how sophisticated a lesson he or she is learning.

So many popular books on ecology perpetuate the myth that ecosystems are stable and balanced, until the evil human species interferes. Moore knows he cannot defend that position, and so is more honest with his readers. As a result, his treatment of disturbance in ecosystems is most impressive. For the same reason, his concluding section on Man and Nature is more satisfactory than others of its kind I have read.

Over half the book is devoted to a series of essays on the major biomes, including marine systems. As with the rest of the book, these are beautifully illustrated and up to date. There is a good discussion, for example, of the non-solar chemosynthetic ecosystems on the deep ocean floor around thermal vents.

My only quibble is about the "animal" in the title. I suspect it was put there by the publisher, not by Moore or the other contributors. There is nothing in the text, or in modern ecological science for that matter, to justify such taxonomic discrimination. It is the only antique note in the whole book.

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American Sportsmen and the Orgins of Conservation

By John F. Reiger. 1986. Revised edition. University of Oklahoma Press, Norman. 316 pp., illus. U.S. $11.95.

American Sportsmen and the Origins of Conservation was first published in 1975 as a kind of corrective. Disturbed by the way in which anti-hunting and animal rights groups were denigrating the American sportsman, John F. Reiger decided to examine the central role that hunters and fishermen played in the early conservation movement. In this revised edition, Reiger has made a number of minor changes, but his basic arguments remain strong and clear.

Whereas most histories of the American conservation movement start at the beginning of the twentieth century with Teddy Roosevelt's assumption of the American presidency, Reiger focuses on the preceding three decades (1870-1900). He suggests that conservation owes its origins to upper class, well-to-do sportsmen who became increasingly alarmed about the disappearance of wildlife and formed such organizations as the Boone and Crockett Club to promote conservation practices. He also argues that these early conservationists were not preservationists — rather, they believed that America's game and fish resources should be protected and carefully managed but "used" nonetheless. Finally, Reiger notes that such heralded conservation figures as Teddy Roosevelt, Gifford Pinchot and Bernhard Fernow were avid sportsmen; even the saintly Aldo Leopold loved hunting.

Reiger's text is quite short — a mere 151 pages. It is, however, complemented by a lengthy "Picture Album of Sport and Game", which illustrates and expands upon several of the main arguments of the text. There are also nearly 100 pages of notes and bibliography (annotated). Together, they make for an instructive and extremely useful publication.

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Population Ecology: A Unified Study of Animals and Plants

By Michael Begon and Martin Mortimer. 1986. Second edition. Sinauer, Sunderland, Massachusetts. 220 pp., illus. U.S. $19.95.

A zoologist and a botanist have made an extremely well co-ordinated effort in presenting the population ecology of both animals and plants under one title. This textbook reads so smoothly that the reader soon forgets that it was written by two authors instead of one.

Undergraduate students with little or no prior knowledge of the subject are the targeted audience of this book, yet the coverage given to current topics in this field and the use of recent field data ought to interest a wider audience. In any discussion of population ecology, it is difficult to avoid using mathematical equations to illustrate important principles. The authors rely on mathematical examples very heavily. However, the authors keep their use of mathematics restricted to the last half of each chapter in order to avoid turning away readers from the subject matter of each chapter. In addition, the authors keep their mathematical expressions simple enough to be understood by readers with little or no exposure to calculus.

This book contains three parts. Part one explores the interactions that occur in single-species populations. The second part investigates interspecific interactions. The last part uses the principles discussed in the first two parts to analyze various life-history strategies, population regulation, and community structure.

In the first part, the reader learns how to describe populations with diagrammatic and conventional life tables. The authors stress the importance of clearly defining the individual that is being counted, especially when dealing with the modular growth forms that are common amongst plants. The sophistication of the population descriptions increases when intraspecific competition is considered. It expands further after the incorporation of age-specific fecundity and mortality in a very clear explanation of the various kinds of matrix models that can be used to describe fluctuations in populations.

Additive and substitutive experiments reveal effects of interspecific competition such as competitive exclusion, resource partitioning, and character displacement. This is followed by an in-depth review of the effects of predators, parasitoids, parasites, and herbivores on prey populations. These effects are characterized by their stabilizing or destabilizing impacts on populations. Against this background, the authors review the effects on populations made by modern man's harvesting of wild plant and animal populations.

In the third section, the usefulness and limitations of the "r-" and "k-" selection concepts are explained very well in a discussion of life-history strategies. Then, most of the principles covered in the book are brought together in an excellent discussion of population regulation in the Colorado Potato Beetle. The book finishes with examples of how aspects of population ecology will facilitate our understanding of community ecology.

The discussion of the Colorado Potato Beetle is the best synthesizing example presented in the third section. It contains a life table with ten years of reliable data including eleven different mortality factors. These factors include cannabilism and emigration which are the result of intraspecific interactions and parasitism and predation which are the result of interspecific interactions. The mortality factors are then analyzed to find the key factor causing changes in population size. From this information, predictive population models are built.

The authors' judicious use of mathematical models successfully accomplishes their goal of demonstrating how models can be used to further our understanding of nature. Yet, the concise writing style and the very liberal use of numerous graphs, tables, and diagrams make this textbook pleasurable to read and easy to understand. Consequently, this book is accessible reading to anyone interested in population ecology.

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Natural History of Vacant Lots

By M. F. Vessel and H. H. Wong. 1987. University of California Press, Berkeley. xii + 284 pp., illus. + plates. U.S. $22.50.

Vacant lots occur throughout urban areas. Long ago children discovered that they are great places to play in and that fascinating creatures often live there. These facts have largely gone unnoticed to adults until recently.

The adult world is starting to catch up the childhood world. The *Natural History of Vacant Lots* is an introductory statement on the ecology and natural history of derelict sites within urban areas. The book states that on the average, 20% of the land in urban areas occurs in such forms as: "military property, abandoned lands, and derelict land adjacent to waterfronts, as well as unused streets, waysides, reservoirs, and even rooftops".

The book appears to have been written for the teacher of children who may wish to teach about, and in, this common urban environment and for the amateur naturalist who wishes to learn more about these areas.

The title of the book is misleading because the subject matter deals with vacant lots in California only. The book is number 50 in the impressive series of California Natural History Guides published by the University of California Press.

The guide has two major parts. The first section presents a general introduction to ecology, some characteristics of weedy plants, learning activities for classes, and a long list of the species that can be found on vacant lots in California. The species list is given in the form of a table that shows the likely occurrence of each species in the urban lots of six different zones of California (coastal, valley, foothill, desert, mountain, and Los Angeles). This list of the species that occur in these habitats is probably the most valuable part of the manuscript. The authors appear to have considerable experience in the subject matter and a comprehensive list such as this is very useful.

The second section contains 170 pages of descriptions of the species that are most likely to be found on vacant lots in California. Each description is the usual collection of species morphology, habitat, and interesting natural history tidbits. All species are illustrated with either a drawing or a photo.

The book is written in an introductory level with an admirable attempt to reduce biology jargon (i.e., scientific terminology) to a manageable level. However, the book still requires a 4.5 page dictionary of the technical terms used.

Scientific names are used abundantly throughout the text. They are used much too often for the level for which the book is intended, and nowhere is there an explanation of how to use such names. I find in my teaching that the majority of students, even at the university level, do not know about family, genus, and species names and the protocol for their use. The inclusion of such names makes the book much more difficult to use and is sure to cause problems for many users. It would have been more appropriate to use one table that contains all common names and the equivalent scientific names, as the translation device for those who desire such information.

The species illustrations vary in form and style. Some are ink drawings. Others are colour photographs. Some are black-and-white photographs. The drawings are placed in the text near the species discussion while all the photographs are placed together in a group of plates at the centre of the book. None of the illustrations have a scale. Some show the flower of a plant, others seeds, some half the plant, and a few show the whole plant. None show the entire plant, with close-up views of the significant field marks. None of the illustrations show different views of the species throughout the year. Although much of the observation of plants will take place outside the flowering season, the authors have decided to provide no assistance to the students of this book at those times of the year. All of this adds up to confusion. It is probable that for many identifications this book is inadequate and that other guides that deal specifically with various life forms will have to be used.

The suggested activities for students of vacant lots look like they came out of a 1920s outdoor science manual. They tend to concentrate on species identification, collecting and storing pieces of nature, and observing "biotic relationships". No reference is made to experiential learning, such as students assuming the roles of the species in the area. These and the many other techniques developed for environmental education in the last 20 years are ignored.

The section of the book which attempts to explain basic ecological principles appears to be unnecessary. If the reader is totally unfamiliar with these principles then it is doubtful that such a short section is adequate. Correspondingly, this section does not do a good job of describing the specific ecological attributes of vacant lots. The ecology of a vacant lot has many components that are fundamentally different from other less man-modified systems and this book does not address these in much depth.

Unfortunately, this book comes off second best in comparison to its British counterpart, Owen's *The Natural History of Britain and Northern Europe Towns and Gardens*. Owen's book has a rich description of urban ecology that is based on a full knowledge of the literature. All species illustrations are in full colour, in environmental situations that provide scale, and are on the page opposite the written description. These are all features which Vessel and Wong's book is lacking.

A natural history guide that attempts to deal with an ecosystem type suffers from the fact that it must deal with so many species and therefore must either cut some out or deal with each in a very cursory manner. Fortunately for the authors, vacant lots have relatively depauperate floras and faunas so that it is possible to cover all of the relevant species.

Such a book only succeeds if it deals with the subject matter in such a way that it is clear to the reader that the entire book is one exposition in a tightly integrated fashion around the uniqueness of a specific community. Unfortunately, Vessel and Wong's book provides little more, and in many cases quite a bit less, than that provided in the regular field guides dealing with plants, birds, and so on. In addition, it does not make a convincing case that vacant lots are unique ecosystems. It appears to ignore much of the literature on the specific attributes of the ecology of derelict landscapes.

The concentration of the book on California means that the utility of the information for the rest of North America is quite limited.

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The Arctic and its Wildlife

By Brian Sage. 1986. Facts on File, New York. 192 pp., illus. U.S. $24.95; $34.95 in Canada.

Visiting the Arctic with its many different landscapes, ecosystems, and harsh climate is the dream of many armchair naturalists, and Brian Sage's book, illustrated by colourful panoramic photographs, reawakens the dream. Beginning with a presentation of physical geography, the Arctic is shown to have a great diversity of landforms and sea habitats distributed around the pole. Rather than limiting the scope to Alaska and the Canadian Arctic, the book attempts to focus on the global picture. It soon becomes apparent, however, that the majority of Sage's experience and research has been done in Alaska and that he is most comfortable dealing with topics from the Beaufort Sea and Alaska regions of the Arctic.

The strength of the book is the picture given to the reader of the Arctic as a distinct geographical region in terms of land forms and temperature. Instead of an Arctic Circle of latitude, we are given the image of an irregularly varying line encompassing many latitudes but following landforms and temperature gradients which vary considerably throughout the area. Constant throughout the description is the effect of depressed temperature on the land and the sea with their plant and wildlife.

The chapters on Arctic flora, insects, and aquatic mammals were not written by the author but were contributed and edited into the book. Of the three, the chapter on flora fits the pattern of the first few chapters the best. Most of the emphasis is given to the adaptations of the plants to the Arctic environment using representative species. One has to look outside the book to find a species list. The book only provides numbers of species present to contrast the Arctic environment to more temperate regions.

While insects are given an entire chapter, their treatment is not very extensive. Many references dwell on which types of insects are absent rather than which are present. Reading about what is not there gets tedious very quickly.

The introduction tells the reader that the chapter on birds is shortened and the information is found elsewhere. Quick arithmetic showed the chapter on birds to be the longest in the book; in addition there is a species list of birds in the appendix. A lot of good general information is included as well as current research on populations and breeding densities.

While the breeding research looked good for the chapter on birds, close adherance to available breeding research seems to limit the information in the discussion of Arctic mammals. As each species is listed and discussed, only a few significant points are given about reproduction and natural history without much editing to standardize the data. For instance, Grizzly Bears are described as having been subject to detailed breeding research, but no gestation period nor yearly cycle pattern is given. Polar Bears are described in their yearly cycle but again without the gestation period listed. For both bears, we are given a discussion titled "Denning Habits" but the Polar Bears denning habits are given in connection with breeding biology while the discussion on the Grizzly Bear dens is much more general. Gestation periods are listed for Moose, Caribou, Arctic Fox, and other species.

The book seems to give a broad picture of the Arctic and the adaptations which wildlife and plant life have made to that environment. The level of writing seems to be directed to the general interest of the public but with fairly detailed research included for the university student or professional. The section on adaptations and geography will be suitable for the high school level. Standardization would be an asset for using the book as a reference; comparison studies on the different animals would require extra digging outside the book. The book is attractive, with much impressive photography and good background information for the non-professional. As well, the 38 figures and 30 tables have much to offer in up-to-date research for the serious student of the Arctic.

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Viable Populations For Conservation

Edited by Michael E. Soulé. 1987. Cambridge University Press, Cambridge. 189 pp., illus. Cloth U.S. $45; paper U.S. $18.

Determining the minimum viable population (MVP) could easily replace the title for this book. The book deals with methods and arguements for using and determining the MVP.

Michael Soulé has edited this book with managers and scholars in mind. His aim was to provide an intellectual challenge as well as produce a text useful to professionals in the field of conservation biology. Each chapter has therefore been written by leading American scholars specializing in their own field of experience.

As the above indicates, *Viable Populations for Conservation* is highly technical. Modeling methodologies are discussed, starting with the simplest and ending with the most comprehensive. Models cover the areas of environmental impact, catastrophes, genetic variation, and spatial interactions.

The authors of the individual chapters have made a concerted effort to build upon foundations laid by the preceding chapters. This adds greatly to the readibility of the book.

Each chapter has been provided with a list of references for detailed background and theoretical reading. An effort has been made to provide case studies and examples where possible.

Soulé has also provided a summary chapter discussing shortcomings of the models and emphasize the need for continuous testing to ensure models depict the situation, for which they are used, as closely as possible.

I believe Michael Soulé has provided a book which will be a useful tool and reference for those involved in decision making for the field of conservation biology.

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Rangelands: A Resource Under Siege

Edited by P. J. Joss, P. W. Lynch, and O. B. Williams. 1986. Proceedings of the Second International Rangelands Congress. Cambridge University Press, New York. 634 pp., illus. U.S. $79.50.

The Proceedings of the Second International Rangeland Congress, held at Adelaide, South Australia, 13-18 May 1984, is a compilation of the invited and thematic papers presented in 13 symposia. The congress was truly international with presentations by representatives from 40 of the 42 countries in attendance. Only invited and lunchtime addresses are printed in full, while contributed papers are published as unrefereed synopses, each approximately one page in length.

The objectives of the Congress were to strengthen and accelerate worldwide exchange of knowledge concerning rangelands, to create a medium for continuing exchange of viewpoints between independent societies and individuals interested in the use, improvement, and conservation of rangeland resources, and to bring people and ideas together so that all can benefit from the international expertise and thus strengthen range management over the world.

The 13 symposia, with number of papers in parentheses, were as follows: Dynamics of Range Ecosystems (51); Grazing Industries (27); Mining and Rangelands (14); Primary Producers (12); Management of Grazing Systems (30); Technological Improvements of Arid Rangelands (36); Unesco Man and the Biosphere Program (18); Animal Production (28); Ecophysiology of

Rangeland Plants (25); Developing World Challenges (13); Range Resources Monitoring and Administration (21); Conservation and Wildlife (20); and Fire in Arid and Semi-Arid Regions (22).

The book presents excellent papers which recognize that the problems of rangelands will not be solved by simple technological fixes but that the long-term stability and productivity of this resource require sound management based on a thorough understanding of whole systems. Much of the data indicated that rangelands worldwide, even in developing countries, may be improving slightly. The numerous papers provided much variability and diversity of opinion on several subjects and are a valuable source of material for those seriously interested in rangeland management.

While the book contains a Table of Contents listing the titles of the symposia and an Author Index, it does not list the titles of the papers nor does it contain a Subject or General Index to readily locate a topic or paper. This is frustrating in that one has to peruse the whole book before the contents can be identified. Despite this serious limitation, I recommend the book to interested ecologists and range management professionals as well as those interested in resource management.

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MISCELLANEOUS

The Art of Survival/La survivance et l'art

Edited by Raymonde Lanthier. 1987. Canadian Wildlife Associates, Waterloo, Ontario. 64 pp., illus. Cloth $21.95; paper $11.95; signature edition $1500.

Based on a Canadian Wildlife Service art exhibition at the Royal Ontario Museum in Toronto, this collection represents under one cover some of the best of Canada's talented wildlife artists. This is part of a collection, by artists in aid of wildlife, that was made to commemorate the founding of the first wildlife sanctuary in North America at the Last Mountain Lake, Saskatchewan in 1887. The book was produced by volunteers with proceeds going to the World Wildlife Fund Endangered Species Recovery Fund — a commendable idea well worth supporting.

Introductory materials by Governor General Jeanne Sauvé, the Honourable Tom McMillan, and Yorke Edwards include a list of 138 Canadian endangered species (25 which were added in 1987, with only one, the white pelican, recovered sufficiently to be removed from the list at that time). The text emphasizes the importance of wildlife protection for the enjoyment of all Canadians.

Wildlife art became popular in illustrations for faunal or outdoors publications long before the camera was available. It has survived and expanded in demand in spite of photographic technology. It allows representation of species as the eye sees them without problems of shadows, poses, or the elusiveness of the animals themselves.

Each of the 19 artists represented is presented on two facing pages. One page presents a representative painting while the other provides a short biography and a photo of the artist. The art is reproduced in excellent quality while the written material is short and informative without being cluttered. Perhaps a little more could have been added, such as why each single painting was selected from the many works available and whether these were selected by the artists or publishers. It is also interesting that only five of the depicted species (six paintings, including two of a cougar,) are endangered (including the non-Canadian Giant Panda). One would think with 138 to choose from more could have been included.

This is an excellent and highly recommended example of Canadian wildlife art. It is of timeless value as a coffee-table book for anyone with love of art or wildlife. The cause and book are each well worth the price and our support.

WILSON EEDY

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Weatherwatcher's Diary

By Carol Thiessen. 1987. National Museum of Natural Sciences, Ottawa. $7.95.

This diary/agenda provides a place to record the weather and appointments for each day of the year. It also delivers a modest amount of weather lore and trivia. The blank book measures 23 cm × 20 cm × 15 mm, making it more suitable for desk use than in pocket or briefcase. Not as glossy as some diaries published by environmental groups (it has only one colour photograph per month), the book does have porous paper, which accepts damper inks without smearing.

Daily entries are organized into boxes for temperature, wind, precipitation and pressure, followed by twelve blank lines — two days per page. Where it occurs, weather trivia information is distributed through the ample margins at a rate of approximately one trivial item every four days.

The trivia included is rather less than that delivered by the Atmospheric Environment Service's annual trivia calender. Canadian records of the four measured categories are noted. Weather myths are generally endorsed or debunked in marginal notes, although the book erroneously claims that stepping on spiders does not cause rain. The only holidays noted are Christmas and World Meteorologic Day. Appended are a cloud chart, a Beaufort scale, a small bibliography and a perpetual calendar indexed from 1800 to 2050 AD.

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NEW TITLES

Zoology

†**Adaptive strategies and population ecology of northern grouse, volume 1: population studies** and **volume 2: theory and synthesis.** 1987. Edited by Arthur T. Bergerud and Michael W. Gratson. University of Minnesota Press (Canadian distributor, Beaverbooks, Markham, Ontario). 392 pp., illus. each. Cloth combined volume $86.95; paper individual volumes $26.50 each.

Animal evolution changing environment: with special reference to abnormal metamorphosis. 1987. By Ryuichi Matsuda. Wiley, New York. xviii + 355 pp., illus. U.S.$44.98.

Audubon wildlife report 1988/1989. 1988. Edited by William J. Chandler. Academic Press (Harcourt and Brace Jovanovich, San Diego). c848 pp., illus. cU.S.$49.95.

†**The bald eagle: haunts and habits of a wilderness monarch.** 1988. By Jon M. Gerrard and Gary R. Bortolotti. Smithsonian Institution Press, Washington. xiv + 177 pp., illus. U.S.$12.95.

The biology of perch and other related fish. 1987. By John Craig. Croom Hilm and Timber Press, Portland, Oregon. xviii + 333 pp., illus. U.S.$42.50.

†**Birds of the Middle East and North Africa.** 1988. By P. A. D. Hollom, R. F. Porter, S. Christensen, and Ian Willis. Buteo, Vermillion, South Dakota. 280 pp., illus. + plates. U.S.$32.50.

***The breeding bird survey: its first fifteen years, 1965–1979.** 1986. By Chandler S. Robbins, Danny By Strak, and Paul H. Geissler. Resource Publication 157. United States Fish and Wildlife Service, Washington. 196 pp., illus.

†**Breeding waders in Europe: a review of population size estimates and a bibliography of information sources.** 1986. By Theunis Piersma. Nature Conservancy Council, Whitechurch, United Kingdom. 116 pp., illus. £5.

†**The Collins guide to the birds of Britain and Europe with North Africa and the Middle East.** 1988. (Reissue of 1984 revised edition). By Hermann Heinzel, Richard Fitter, and John Paralow. Collins (American distributor, Penguin, New York). 320 pp., illus. + maps. U.S.$15.95.

†**The Collins field guide to the birds of south-east Asia.** 1988. (Reissue of 1975 publication). By Ben King, Martin Woodcock, and E. C. Dickinson. Penguin, New York. 480 pp., illus. + plates. U.S. $19.95.

***The Collins field guide to the birds of West Africa.** 1988. (Reissue of 1977 publication). By W. Serle, G. J. Morel, and W. Hartwig. Penguin, New York. 351 pp., illus + plates. U.S.$19.95.

†**The Collins field guide to the mammals of Africa including Madagascar.** 1988. (Reissue of 1980 edition). By Theodor Haltenorth and Helmut Diller. Collins (American distributor, Penguin, New York). 400 pp., illus.

The Collins field guide to the national parks of east Africa. 1988. (Reissue of 1981 revised edition). By J. G. Williams. Collins (American distributor, Penguin, New York). 336 pp., illus.

†**The Collins guide to the rare mammals of the world.** 1988. By John A. Burton and Bruce Pearson. Collins (American distributor, Penguin, New York). 240 pp., illus. U.S.$25.

†**The coyote: defiant songdog of the west.** 1988. By Francois Leydet. Revised edition. University of Oklahoma Press, Norman. 224 pp., illus. Cloth U.S. $19.95; paper U.S.$8.95.

The domestic cat: the biology of its behavior. 1988. Edited by Dennis C. Turner and Patrick Bateson. Cambridge University Press, New York. c250 pp., illus. Cloth cU.S.$75; paper cU.S.$32.50.

Dynamics of forest insect populations: patterns, causes, implications. 1988. Edited by Alan A. Berryman. Plenum, New York. c596 pp. U.S.$97.50.

Ecology of forest insects. 1987. By Andrezej Szujecki. Translated from 1980 Polish edition by Albert Radziwiff. Junk (distributed by Kluwer, Boston). xiv + 601 pp., illus. U.S.$185.

*****Enjoying the birds of the Ottawa valley.** 1988. By John Sankey. Author, 1369 Matheson Road, Gloucester. 128 pp., illus. $7.95.

†**Eric Hosking's birds of prey of the world.** 1988. By Eric Hosking, David Hosking, and Jim Flegg. Stephen Green Press (distributed by Penguin, New York). 176 pp., illus.

†**The field guide to the birds of east Africa.** 1988. (Reissue of 1980 edition). By J. G. Williams and N. Arlott. Collins (American distributor, Penguin, New York). 415 pp., illus.

†**Guide to the mammals of Pennsylvania.** 1987. By Joseph F. Merritt. University of Pittsburgh Press, Pittsburgh. xviii + 408 pp., illus. Cloth U.S.$34.95; paper U.S.$14.95.

Frogfishes of the world: systematics, zoogeography, and behavioral ecology. 1987. By Theodore W. Pietsch and David B. Grobecker. Stanford University Press, Stanford. xxiv + 420 pp., illus. + plates.

†**Handbook of mammals of the north-central states.** 1987. By J. Knox Jones, Jr. and Elmer C. Birney. University of Minnesota Press (Canadian distributor, Beaverbooks, Markham, Ontario). c308 pp., illus. Cloth $43.50; paper $23.50.

†**Handbook of North American birds, volumes 4 and 5: diurnal raptors parts 1 and 2.** 1988. Edited by Ralph S. Palmer. Yale University Press, New Haven. 433 pp., illus. + 465 pp., illus. U.S.$80 set.

Introduction to the study of Meiofauna. 1988. By Robert P. Higgins and Hjalmar Thiel. Smithsonian Institute Press, Washington. 376 pp., illus. U.S. $39.95.

†**The Kookaburra's song: exploring animal behavior in Australia.** 1988. By John Alcock. University of Arizona Press, Tucson. 200 pp., illus. U.S.$19.95.

†**The last grizzly and other southwestern bear stories.** 1988. Edited by David E. Brown and John A. Murray. University of Arizona Press, Tucson. 190 pp., illus. U.S.$24.95.

*****Living snakes of the world in color.** 1988. By John M. Mehrtens. Sterling, New York. 480 pp. Illus. U.S.$50 in U.S.A.; U.S.$70 elsewhere.

†**The lobster gangs of Maine.** 1988. By James M. Acheson. University Press of New England, Hanover, New Hampshire. xiv + 181 pp., illus. Cloth U.S.$20; paper U.S.$9.95.

*****The loon — voice of the wilderness.** 1986. By Jean Dunning. Yankee Publishing, Dublin, New Hampshire. 143 pp., illus. U.S.$16.95.

Megaherbivores: the influence of very large body size on ecology. 1988. By N. Owen-Smith. Cambridge University Press, New York. c360 pp., illus. cU.S. $62.50.

Natural history of vampire bats. 1988. Edited by Arthur M. Greenhall and Use Schmidt. CRC Press, Boca Raton, Florida. c272 pp., illus. cU.S.$145 in U.S.A.; cU.S.$170 elsewhere.

North American owls: biology and natural history. 1988. By Paul A. Johnsgard. Smithsonian Institute Press, Washington. 304 pp., illus. U.S.$45.

Observing marine invertebrates: drawings from the laboratory. 1987. Edited by Donald F. Abbott and Galen Howard Hilgard. Stanford University Press, Stanford. xxvi + 380 pp., illus. U.S.$29.50.

†**Papers from the 1987 conference on loon research and management.** 1988. Edited by Paul I. V. Strong. Project Loon Watch, Northland College, Ashland, Wisconsin. 214 pp., illus. U.S.$20.

A primate radiation: evolutionary biology of the African guenons. 1988. Edited by A. Gautier-Hion, F. Bourliere, J.-P. Gautier, and J. Kingdon. Cambridge University Press, New York. c550 pp., illus. cU.S.$100.

Reindeer in South Georgia: the ecology of an introduced population. 1988. By N. Leader-Williams. Cambridge University Press, New York. c275 pp., illus. cU.S.$32.50.

***Saving America's wildlife.** 1988. By Thomas R. Dunlap. Princeton University Press, Princeton. xvi + 222 pp. U.S.$24.95.

Smith's sea fishes. 1986. Edited by M. M. Smith and P. C. Heemstra. Sixth edition. Springer-Verlag, New York. 1047 pp., illus. U.S.$105.

†**Suivi de la pêche sportive dans les eaux de la région de Montréal en 1985.** 1987. Par Pierre Fournier, Michel Beaudoin, et Louis Cloutier. Rapport Technique 06-42. Ministère du Loisir, de la Chasse, et de la Pêche, Montréal. ix + 76 pp., illus.

Water pollution and fish physiology. 1987. By Alan G. Heath. CRC Press, Boca Raton, Florida. 272 pp. U.S.$145 in U.S.A.; U.S.$165 elsewhere.

Wildlife production systems: economic utilization of wild ungulates. 1988. Edited by R. J. Hudson, K. R. Drew, and L. M. Baskin. Cambridge University Press, New York. c400 pp., illus. cU.S.$75.

Botany

Algae and human affairs. 1988. Edited by Carol A. Lembi and J. Robert Waaland. Cambridge University Press, New York. c585 pp., illus. cU.S.$64.50.

Aspergillus and Aspergillosis. 1988. Edited by H. Vanden Bossche, D. N. R. Mackenzie, and G. Cauwenbergh. Proceedings of a symposium, University of Antwerp, Belgium, 28 June to 1 July 1987. Plenum, New York. c308 pp. U.S.$59.50.

Atlas florae Europaeae, volume 1: distribution of vascular plants in Europe: Pteridophyta, Gymnospermae, and volume 2: distribution of vascular plants in Europe: Salicaceae to Basellaceae. 1988. Edited by J. Halas and J. Sudminen. Cambridge University Press, New York. c164 pp., and c314 pp. cU.S.$54.50 and cU.S.$72.

†**Atlas of rare vascular plants of Ontario, Part 4.** 1987. Edited by K. M. Pryer and G. W. Argus. National Museum of Natural Sciences, Ottawa. $5.

Biology of polar bryophytes and lichens. 1988. By R. E. Longton. Cambridge University Press, New York. c280 pp., illus. cU.S.$54.

†**Catalogue bibliographique des bryophytes du Québec et du Labrador.** 1988. Par Marc Favreau et Guy R. Brassard. Occasional Papers in Biology No. 12. Memorial University, St. John's. 114 pp. $5.50.

†**Checklist of the vascular plants of Algonquin Provincial Park.** 1988. By Daniel Brunton. Algonquin Park Technical Bulletin No. 4. Friends of Algonquin Park, Whitney, Ontario. 29 pp. $1.

Filamentous fungi. 1988. Edited by D. L. Hawksworth and B. E. Kirsop. Cambridge University Press, New York. 224 pp., illus. U.S. $29.95.

†**The flora of the Tobermory islands, Bruce Peninsula National Park.** 1987. By J. K. Morton and Joan M. Venn. Biology Series No. 31. University of Waterloo, Waterloo. 92 pp., illus. $15.

Green photosynthetic bacteria. 1988. Edited by J. M. Olson, J. G. Ormerod, J. Amesz, E. Stackebrandt, and G. H. Truper. From a symposium, Nyborg, Denmark, 19–21 August 1987. Plenum, New York. c320 pp. U.S.$69.

†**Growing Canada's floral emblems.** 1988. By Lawrence C. Sherk. Canadian Wildflower Society, Unionville, Ontario. 35 pp., illus. $12.

Growth and reproduction strategies of freshwater phytoplankton. 1988. Edited by Craig D. Sandgren. Cambridge University Press, New York. c384 pp., illus. cU.S.$49.50.

Guide to the identification of plant macrofossils in Canadian peatlands. 1988. By P. E. M. Levesque, H. Dinel, and A. Larouche. Canadian Government Publishing Centre, Ottawa. 65 pp., illus. $9.95 in Canada; $11.95 elsewhere. English or French.

Introduction to plant population ecology. 1987. By Jonathan W. Silvertown. Second edition. Longman Scientific and Wiley, New York. xii + 229 pp., illus. U.S.$19.95.

100 families of flowering plants. 1988. By Michael Hickey and C. J. King. Second edition. Cambridge University Press, New York. 624 pp., illus. cU.S.$75.

Patterns in plant development. 1988. By Taylor A. Steeves and Ian M. Susser. Second edition. Cambridge University Press, New York. c284 pp., illus. Cloth cU.S.$39.50; paper cU.S.$14.95.

†**Plantwatching: how plants remember, tell time, form relationships, and more.** 1988. By Malcolm Wilkins. Facts on File, New York. 207 pp., illus.

***Postglacial vegetation of Canada.** 1987. By J. C. Ritchie. Cambridge University Press, New York. 178 pp., illus. U.S.$70.

Public policy and the misuse of forest resources. 1988. Edited by Robert Repetto and Malcolm Gillis. Cambridge University Press, New York. c200 pp. Cloth cU.S.$35.95; paper cU.S.$12.95.

†**Weeds.** 1987. By Walter Conrad Muenscher. Second edition. Cornell University Press, Ithaca. 608 pp., illus. U.S.$16.95.

***World directory of palynologists.** 1988. By Bernard J. Crilley and Robert A. Fensome. International Federation of Palynological Societies. xvi + 259 pp.

†**The world of northern evergreens.** 1988. By E. C. Pielou. Comstock (Cornell University Press, Ithaca). x + 174 pp., illus. Cloth U.S. $36.50; paper U.S.$10.95.

Yeasts. 1988. Edited by B. E. Kirsop and C. P. Kurtzman. Cambridge University Press, New York. c256 pp., illus. cU.S.$29.95.

Environment

†**The acid rain controversy.** 1988. By James L. Regens and Robert W. Rycroft. University of Pittsburgh Press, Pittsburgh. xviii + 228 pp., illus. Cloth U.S.$24.95; paper U.S.$12.95.

Advances in microbial ecology, volume 10. 1988. Edited by K. C. Marshall. Plenum, New York. c438 pp. $75.

Aquatic toxicology and hazard assessment, volume 10. 1988. Edited by William J. Adams, Gary A. Chapman, and Wayne G. Landis. STP 971. ASTM, Philadelphia. 586 pp., illus. U.S. $64.

†**The biogeography of the island region of western Lake Erie.** 1988. Edited by Jerry F. Downhower. Ohio State University Press, Columbus. viii + 280 pp., illus. U.S.$65.

Biological monitoring of toxic metals. 1988. Edited by Thomas W. Clarkson, Lars Friberg, Gunnar F. Nordberg, and Polly R. Sage. Proceedings of a conference, Rochester, 2–5 June 1986. Plenum, New York. c662 pp. U.S. $115.

Biological surveys of estuaries and coasts. 1987. Edited by J. M. Baker and W. J. Wolff. Cambridge University Press, New York. xx + 449 pp., illus. U.S.$69.50.

Cross-border litigation: environmental rights in the Great Lakes ecosystem. 1987. By Paul R. Muldoon, David A. Scriven, and James M. Olsen. Carswell, Toronto. 445 pp. $78.

†**Desert solitaire.** 1988. By Edward Abbey. Revised edition. University of Arizona Press, Tucson. 300 pp., illus. U.S.$24.95.

Developments in river basin management. 1988. Edited by N. L. R. Nucci, K. Uehara, and W. S. Casadei. Proceedings of a conference, Sao Paulo, Brazil, 13–15 August 1986. Pergamon Press, Elmsford, New York. 288 pp., illus. U.S.$54.

Ecology, community, and lifestyle: outline of an ecosophy. 1988. By Arne Naess and David Rothenberg. Cambridge University Press, New York. c240 pp., illus. cU.S.$44.50.

The ecology of Sulawesi (Celebes). 1987. By Anthony J. Whitten, Muslimin Mustafa, and Gregory S. Henderson. Sinauer, Sunderland, Massachusetts. xx + 802 pp., illus. Cloth U.S. $50; paper U.S.$25.

The ecology of Sumatra. 1987. By Anthony J. Whitten, Sengli J. Damanik, Jazanul Anwar, and Nazaruddin Hisyam. Sinauer, Sunderland, Massachusetts. xiv + 587 pp., illus. Cloth U.S.$45; paper U.S.$22.

The effects of contaminants on ecological systems. 1988. Edited by E. E. Herricks. Proceedings of a conference, Blacksburg, Virginia, 17–19 November, 1986. Pergamon Press, Elmsford, New York. 136 pp., illus. U.S.$54.

Galapagos: discovery on Darwin's islands. 1988. By David W. Steadman and Steve Zousmer. Smithsonian Institute Press, Washington. 208 ppp., illus. U.S. $24.95.

Glacier Bay: icy wilderness. 1988. By Alaska Northwest Publishing, Edmonds, Washington. 103 pp., illus. + map. U.S.$14.95; $18.95 in Canada.

***Green justice: the environment and the courts.** 1987. By T. M. Hoban and R. O. Brooks. Westview Press, Boulder, Colorado. xv + 250 pp. Cloth U.S. $44; paper U.S.$16.95.

†**The Maine woods.** 1988 (Reprint of 1964 publication). By Henry David Thoreau. Penguin, New York. xxxiii + 442 pp. U.S. $7.95; $10.95 in Canada.

Marine microbiology. 1988. Edited by B. Austin. Cambridge University Press, New York. 240 pp., illus. Cloth U.S.$59.50; paper U.S.$19.95.

Microbial ecosystems of Antarctica. 1988. By Warwick F. Vincent. Cambridge University Press, New York. c250 pp., illus. cU.S. $49.50.

The microbiology of terrestrial ecosystems. 1987. By B. N. Richards. Longman Scientific and Wiley, New York. xvi + 399 pp., illus. U.S.$44.95.

The ocean basins and margins, volume 7B: the Pacific Ocean. 1988. Edited by Alan E. M. Naim, Francis G. Stehle, and Seiya Uyeda. Plenum, New York. c622 pp. U.S.$95.

†**The outermost house: a year of life on the Great Beach of Cape Cod.** 1988. (Reprint of 1928 publication). By Henry Beston. Penguin, New York. xxiv + 232 pp. U.S.$6.95; $9.95 in Canada.

The provident sea. 1988. By D. H. Cushing. Cambridge University Press, New York. c336 pp., illus. U.S.$65.

†**The river as looking glass and other stories from the outdoors.** 1988. By Craig Woods. Stephen Green Press (distributed by Penguin, New York). vi + 121 pp. U.S.$16.95.

†**Speak to the earth: wanderings and reflections among elephants.** 1988. (Reprint of 1935 publication). By Vivienne De Watteville. Penguin, New York. xxxv + 329 pp., illus. U.S. $7.95.

Trading Canada's natural resources. 1987. Edited by J. Owen Saunders. Carswell, Toronto. 374 pp. $75.

†**The upper Yukon basin.** 1988. By Monty Alford. Alaska Northwest, Edmonds, Washington. 120 pp., illus. $18.95.

Water and the arid lands of the western United States. 1988. Edited by Mohamed T. El-Ashry and Diana C. Gibbons. Cambridge University Press, New York. c475 pp., illus. cU.S.$54.50.

Miscellaneous

The Cambridge atlas of astronomy. 1988. Edited by Jean Audouze and Guy Israel. Second edition. Cambridge University Press, New York. c432 pp., illus. U.S.$90.

The Facts on File dictionary of marine science. 1988. By Barabara Charton and John Tietjen. Facts on File, New York. 336 pp., illus. U.S. $24.95; 33.95 in Canada.

The moon observer's handbook. 1988. By Fred W. Price. Cambridge University Press, New York. c300 pp., illus. cU.S.$27.50.

†**Reproductive success: studies of individual variation in contrasting breeding systems.** 1988. Edited by T. H. Clutton-Brock. University of Chicago Press, Chicago. ix + 538 pp., illus. Cloth U.S.$75; paper U.S.$29.95.

The universe from your backyard. 1988. By David F. Eicher and the editors of Astronomy. Cambridge University Press, New York. c200 pp., illus. cU.S.$24.95.

Books for Young Naturalists

†**Animal vision.** 1988. By Tony Seddon. Facts on File, New York. 62 pp., illus. U.S.$13.95.

†**Birds of prey.** 1988. By Jill Bailey. Facts on File, New York. 62 pp., illus. U.S.$13.95.

†**Extinct animals of the world.** 1988. By Clive Roots. Hyperion Press, Winnipeg. 39 pp., illus. $4.95.

†**Mimicry and camouflage.** 1988. By Jill Bailey. Facts on File, New York. 62 pp., illus. U.S.$13.95.

†**Vanishing animals of the world.** 1988. By Clive Roots. Hyperion Press, Winnipeg. 39 pp., illus. $4.95.

*assigned for review
†available for review

Advice to Contributors

Full details on types of manuscripts suitable for publication and instructions on format have been given most recently in *The Canadian Field-Naturalist* 102(2): 418.

Please take special note of the following changes:

Authors **must share in the cost of publication** by paying $70 for each page in excess of five journal pages, plus $7 for each illustration (any size up to a full page), and up to $70 per page for tables (depending on size). Reproduction of color photos is extremely expensive; price quotations may be obtained from the Business Manager. Reprint order forms are included when galley proofs are sent to authors. If grant or institutional funds are available, we ask authors to defray a higher proportion of the cost of publishing, $70 per page for all published pages. Government institutions are expected to pay the full cost of publication. Authors must also be charged for their changes in proofs.

Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Business Manager when the manuscript is accepted.

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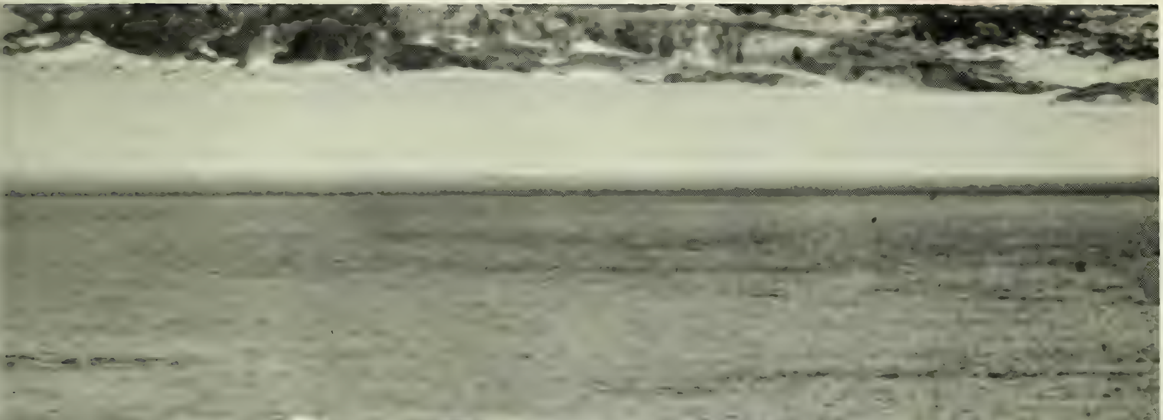

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Back Numbers and Index

Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club*, 1879-1886, and *The Ottawa Naturalist*, 1887-1919, and *Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist* — *Index* compiled by John M. Gillett, may be purchased from the Business Manager.

Cover: White Whales, *Delphinapterus leucas*, in the mouth of the Nastapoka River, eastern Hudson Bay, Photograph by D.W. Doidge (see COSEWIC Status Report by Reeves and Mitchell pp. 220-239).

The Canadian Field-Naturalist

Volume 103, Number 2 April-June 1989

Rare and Endangered Fishes and Marine Mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: V.

R. R. CAMPBELL

Department of Fisheries and Oceans, 200 Kent Street, Ottawa, Ontario K1A 0E6

Campbell, R. R. *Editor.* 1989. Rare and endangered fish and marine mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: V. Canadian Field-Naturalist 103(2): 147-152.

Twelve status reports representing the 1988 fish and marine mammal status assignments have been prepared for publication. Committee and subcommittee activities, including changes to category definitions, are briefly discussed and species lists representing those animals for which reports are in progress and those for which reports are required are presented.

Douze rapports de statut qui représentent toutes les données de statut aux poissons et aux mammifères marins nommés en 1988 ont été préparés pour publication. Les activités du comité et du sous-comité sont brièvement discutées incluyant des changements aux définitions de catégorie, avec des tableaux qui montrent des rapports en cours et les espèces pour lesquelles on en a encore besoin.

Key Words: Rare and endangered species, fish, marine mammals, COSEWIC.

As indicated in previous submissions (Campbell 1984, 1985, 1987, 1988), the intent of the Subcommittee on Fish and Marine Mammals is to publish the status reports (on those species of fish and marine mammals) which the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) have reviewed, approved and used as a basis of assigning status to species in jeopardy in Canada. The group of 12 reports presented herein represents the fish and marine mammal component of those species assigned status in 1988. It is hoped that we will have the continuing support of the Department of Fisheries and Oceans to offer, in succeeding volumes, those reports reviewed in future years (Table 1 presents those species assigned status to April 1988).

Progress

COSEWIC has undertaken to make available to all Canadians supporting information on each species classified (*see* Cook and Muir 1984). The Fish and Marine Mammal Subcommittee has been able to use this journal as one step in achieving the goal. A series of reports were published in 1984, 1985, 1987, and 1988 [*see Canadian Field-Naturalist* 98(1): 63-133; 99(3): 404-450; 101(2): 165-309; 102(1): 81-176; 102(2): 270-398] and the encouraging response to these publications has enabled us to continue.

Additional funding of $40 000 for contracting of status reports was made available in 1987-1988 through matching contributions made by Fisheries and Oceans, Environment Canada, and World Wildlife Fund Canada. This permitted the contracting of 33 new reports and subsequently increased the number of reports in preparation or under review (Table 2), but helped to reduce the number still awaiting consideration. There remain 40 species of fish and 10 of marine mammals (Table 3) for which the subcommittee desires status reports. Although some of these may be of no immediate concern, the subcommittee will, as opportunity allows, attempt to document the status of these species to determine their status in Canada.

There are currently 26 status reports on fish species and 22 on marine mammal species under review or in preparation (Table 2). Some of these will be assigned status in 1989. In addition to soliciting further status reports on species of concern, the subcommittee continues to obtain updates on the status of selected species as new information becomes available. In the past year an updated report on the Sea Otter (*Enhydra lutris*) was reviewed with no change in status.

TABLE 1. Fish and marine mammal species with assigned COSEWIC status to April 1988.

Species	Scientific name	Status	Date assigned
Fish			
Lake Sturgeon	*Acipenser fulvescens*	NIAC’	April 1986
Bloater	*Coregonus hoyi*	NIAC	April 1988
Blueback Herring	*Alosa aestivalis*	NIAC	April 1980
Hornyhead Chub	*Nocomis biguttatus*	NIAC	April 1988
River Chub	*Nocomis micropogon*	NIAC	April 1988
Redfin Shiner	*Notropis umbratilis*	NIAC	April 1988
Green Sunfish	*Lepomis cyanellus*	NIAC	April 1987
Longear Sunfish	*Lepomis megalotis*	NIAC	April 1987
Lake Lamprey*	*Lampetra macrostoma*	Rare	April 1986
Green Sturgeon	*Acipenser medirostris*	Rare	April 1987
Shortnose Sturgeon	*Acipenser brevirostrum*	Rare	April 1980
Spotted Gar	*Lepisosteus oculatus*	Rare	April 1983
Kiyi	*Coregonus kiyi*	Rare	April 1988
Squanga Whitefish*	*Coregonus* sp.	Rare	April 1987
Pacific Sardine	*Sardinops sagax*	Rare	April 1987
Silver Chub	*Hybopsis storeriana*	Rare	April 1985
Umatilla Dace	*Rhinichthys umatilla*	Rare	April 1988
Bigmouth Shiner	*Notropis dorsalis*	Rare	April 1985
Pugnose Shiner	*Notropis anogenus*	Rare	April 1985
Silver Shiner	*Notropis photogenis*	Rare	April 1983**
Pugnose Minnow	*Notropis emiliae*	Rare	April 1985
Redside Dace	*Clinostomus elongatus*	Rare	April 1987
Speckled Dace	*Rhinichthys osculus*	Rare	April 1980†
Central Stoneroller	*Campostoma anomalum*	Rare	April 1985
Blackstripe Topminnow	*Fundulus notatus*	Rare	April 1985
Spotted Sucker	*Minytrema melanops*	Rare	April 1983
River Redhorse	*Moxostoma carinatum*	Rare	April 1983**
Brindled Madtom	*Noturus miurus*	Rare	April 1985
Giant Stickleback*	*Gasterosteus* sp.	Rare	April 1980
Unarmoured Stickleback*	*Gasterosteus* sp.	Rare	April 1983
Lake Simcoe Whitefish*	*Coregonus clupeaformis* spp.	Threatened	April 1987
Blackfin Cisco	*Coregonus nigripinnis*	Threatened	April 1988
Shortnose Cisco	*Coregonus reighardi*	Threatened	April 1987
Shortjaw Cisco	*Coregonus zenithicus*	Threatened	April 1987
Deepwater Sculpin	*Myoxocephalus thompsoni*		
Great Lakes Watershed		Threatened	April 1987
Black Redhorse	*Moxostoma duquesnei*	Threatened	April 1988
Copper Redhorse*	*Moxostoma hubbsi*	Threatened	April 1987
Enos Lake Stickleback*	*Gasterosteus* sp.	Threatened	April 1988
Shorthead Sculpin	*Cottus confusus*	Threatened	Nov. 1983
Aurora Trout	*Salvelinus fontinalis timagamiensis*	Endangered	April 1987*
Acadian Whitefish*	*Coregonus canadensis*	Endangered	April 1983
Salish Sucker	*Catostomus* sp.	Endangered	April 1986
Gravel Chub	*Hybopsis x-punctata*	Extirpated	April 1987***
Paddlefish	*Polyodon spathula*	Extirpated	April 1987
Deepwater Cisco	*Coregonus johannae*	Extinct	April 1988
Longjaw Cisco	*Coregonus alpenae*	Extinct	April 1985
Banff Longnose Dace*	*Rhinichthys cataractae smithi*	Extinct	April 1987
Blue Walleye	*Stizostedion vitreum glaucum*	Extinct	April 1985
Marine Molluscs			
Northern Abalone	*Haliotis kamtschatkana*	N/A	April 1988
Marine Mammals			
California Sea Lion	*Zalophus californianus*	NIAC	April 1987
Steller Sea Lion	*Eumetopias jubatus*	NIAC	April 1987
Atlantic Walrus	*Odobenus rosmarus rosmarus*		
Eastern Arctic		NIAC	April 1987
Northwest Atlantic		Extirpated	April 1987

TABLE 1. *Concluded.*

Species	Scientific name	Status	Date assigned
Grey Whale	*Eschrichtius robustus*		
Northeast Pacific		NIAC	April 1987
Northwest Atlantic		Extirpated	April 1987
Hooded Seal	*Cystophora cristata*	NIAC	April 1986
Northern Elephant Seal	*Mirounga angustirostris*	NIAC	April 1986
Narwhal	*Monodon monoceros*	NIAC	April 1986**
Beluga	*Delphinapterus leucas*		
Beaufort Sea		NIAC	April 1986
St. Lawrence River		Endangered	April 1983
Eastern Hudson Bay		Threatened[i]	April 1988
Ungava Bay		Endangered[i]	April 1988
Blue Whale	*Balaenoptera musculus*	Rare	April 1983
Fin Whale	*Balaenoptera physalus*	Rare	April 1987†
Sea Otter	*Enhydra lutris*	Endangered	May 1978°
Humpback Whale	*Megaptera novaeangliae*		
Northeast Pacific		Threatened	April 1982[-]
Northwest Atlantic		Rare	April 1985
Bowhead Whale	*Balaena mysticetus*	Endangered	April 1980°
Right Whale	*Eubalaena glacialis*	Endangered	April 1980/85[x]
Sea Mink	*Mustela macrodon*	Extinct	April 1985

[1] NIAC — Not in Any COSEWIC Category (i.e., not in jeopardy).

*Endemic to Canada.

N/A Status not assigned. COSEWIC has no mandate for invertebrates. Report accepted and recommended NIAC Status agreed to but not assigned.

†Updated April 1984 — no status change.

[-] Updated April 1985 — North Atlantic stock downlisted to Rare.

[i] to be reviewed in 1989.

[x] Updated April 1985 — no status change.

°Updated April 1986 — no status change

**Updated April 1987 — no status change.

***Updated April 1987 — previous status of Endangered assigned April 1985.

TABLE 2. Fish and marine mammal species for which status reports are in preparation or under review, April 1988.

Species	Scientific name	Proposed status
Fish		
Darktail Lamprey	*Lethenteron alaskense*	Rare
Atlantic Sturgeon	*Acipenser oxyrhynchus*	?
White Sturgeon	*Acipenser transmontanus*	?
Atlantic Salmon	*Salmo salar*	?
Bering Cisco	*Coregonus laurettae*	?
Opeongo Whitefish*	*Coregonus* sp.	Threatened
Pygmy Whitefish	*Prosopium coulteri*	?
Pygmy Smelt	*Osmerus spectrum*	Rare
Jasper Longnose Sucker*	*Catostomus catostomus lacustris*	Rare
Golden Redhorse	*Moxostoma erythrurum*	Rare
Black Buffalo	*Ictiobus niger*	?
Leopard Dace	*Rhinichthys falcatus*	? (B.C.)
Bigmouth Buffalo	*Ictiobus cyprinellus*	Rare
Banded Killifish	*Fundulus diaphanus*	?
Greenside Darter	*Etheostoma blennioides*	?
Least Darter	*Etheostoma microperca*	?
River Darter	*Percina shumardi*	Rare
Margined Madtom	*Noturus insignis*	Rare
Orangespotted Sunfish	*Lepomis humilis*	Rare
Redbreast Sunfish	*Lepomis auritus*	Rare
Striped Bass	*Morone saxatilis*	Endangered
Brook Silversides	*Labidesthes sicculus*	Rare

TABLE 2. *Concluded.*

Species	Scientific name	Possible status
Spoonhead Sculpin	*Cottus ricei*	Rare
Fourhorn Sculpin	*Moxocephalus quadricornis*	Rare
Bering Wolffish	*Anarhichas orientalis*	Rare
Blackline Prickleback	*Acantholumpenus mackyi*	Rare
Bluefin Tuna	*Thunnus thynnus*	?
Marine Mammals		
White-beaked Dolphin	*Lagenorhynchus albirostris*	?
Harbour Porpoise	*Phocoena phocoena*	?
Baird's Beaked Whale	*Berardius bairdii*	?
Blainville's Beaked Whale	*Mesoplodon densirostris*	?
Cuvier's Beaked Whale	*Ziphius cavirostris*	Rare
Hubbs' Beaked Whale	*Mesoplodon carlhubbsi*	?
Sowerby's Beaked Whale	*Mesoplodon bidens*	Rare
Stejneger's Beaked Whale	*Mesoplodon stejegneri*	?
True's Beaked Whale	*Mesoplodon mirus*	?
Beluga Whale	*Delphinapterus leucas*	
Cumberland Sound		Threatened
Western Hudson Bay		NIAC
Ungava Bay°		Endangered
Eastern Hudson Bay/James Bay°		Threatened
Northern Bottlenose Whale	*Hyperoodon ampullata*	?
Bowhead Whale°	*Balaena mysticetus*	Endangered
Killer Whale	*Orcinus orca*	?
Long-finned Pilot Whale	*Globicephela malaena*	?
Right Whale°	*Eubalaena glacialis*	Endangered
False Killer Whale	*Pseudorca crassidens*	?
Dall's Porpoise	*Phocoenoides dalli*	Rare
Risso's Dolphin	*Grampus griseus*	?
Ringed Seal	*Phoca hispida*	NIAC
Sperm Whale	*Physeter catadon*	NIAC
Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	?
Northern Right Whale Dolphin	*Lissodelphis borealis*	?
Striped Dolphin[1]	*Stenella coeruleoalba*	?
Bottlenose Dolphin	*Tursiops truncatus*	?
Short-finned Pilot Whale	*Globicephela macrorhynchus*	Rare
Pygmy Sperm Whale	*Kogia breviceps*	Vulnerable
Dwarf Sperm Whale	*Kogia simus*	Vulnerable
Atlantic White-sided Dolphin[1]	*Lagenorhynchus acutus*	?
Common Dolphin[1]	*Delphinus delphis*	?

*Endemic to Canada.

°Updated Status Report.

TABLE 3. Fish and marine nammal species of interest to COSEWIC (Not By Priority), April 1988.

Species	Scientific name	Possible status
Fish		
Northern Brook Lamprey	*Ichthyomyzon fossor*	Rare (Ontario, Manitoba)
Chestnut Lamprey	*Ichthyomyzon castaneus*	Rare (Manitoba)
Bull Trout	*Salvelinus confluentus*	Rare (Alberta)
Red (Arctic) Char[1]	*Salvelinus alpinus* spp.	? (Landlocked populations — Quebec, New Brunswick, Newfoundland/Labrador)
Lake Herring	*Coregonus artedii*	Endangered in lakes Erie and Ontario but widespread elsewhere
Lake Whitefish	*Coregonus clupeaformis*	Threatened in lakes Erie and Ontario but widespread elsewhere

TABLE 3. *Concluded.*

Species	Scientific name	Possible status
Mira Whitefish*	*Coregonus* sp.	Rare (?)
Spring Cisco[1]*	*Coregonus* sp.	Rare (Ontario and Quebec)
Round Whitefish	*Prosopium cylindraceum*	Rare (lakes Huron and Ontario but widespread elsewhere)
Pygmy Longfin Smelt*	*Spirinchus thaleichthys*	Rare (landlocked population *in* Harrington Lake, British Columbia)
Chain Pickerel	*Esox niger*	Rare (Quebec)
Grass Pickerel	*Esox americanus vermiculatus*	Rare (Ontario, New Brunswick, Nova Scotia)
Redfin Pickerel	*Esox americanus americanus*	Rare (Quebec)
Chiselmouth	*Acrocheilus alutaceus*	Rare (British Columbia)
Bluntnose Minnow	*Pimephales notatus*	Rare (Manitoba)
Cutlips Minnow	*Exoglossum maxillingua*	? (Ontario, Quebec)
Eastern Silvery Minnow	*Hybognathus nuchalis regius*	Rare (Ontario, Quebec)
Western Silvery Minnow	*Hybognathus argyritis*	? (Alberta)
Blackchin Shiner	*Notropis heterodon*	Rare (Manitoba)
Ghost Shiner	*Notropis buchanani*	Rare (Ontario)
Rosyface Shiner	*Notropis rubellus*	Rare (Manitoba)
Striped Shiner	*Notropis chrysocephalus*	Rare (Ontario)
Weed Shiner	*Notropis texanus*	Rare (Manitoba)
Nooky Dace	*Rhinichthys cataractae* spp.	Rare (British Columbia)
Liard Hotspring Lake Chub*	*Couesius plumbeus* spp.	Rare (British Columbia: Liard Hotspring)
Mountain Sucker	*Catostomus platyrhynchus*	Rare (British Columbia, Alberta, Saskatchewan)
Lake Chubsucker	*Erimyzon sucetta*	Rare (Ontario)
Flathead Catfish	*Pylodictis olivaris*	? (Ontario)
Northern Madtom	*Noturus stigmosus*	Rare (Ontario)
Texada Stickleback*	*Gasterosteus* sp.	Rare
Warmouth	*Lepomus gulosus*	? (Ontario)
Eastern Sand Darter	*Ammocrypta pellucida*	Rare (Ontario)
Tessellated Darter	*Etheostoma olmstedi*	Rare (Ontario)
Channel Darter	*Percina copelandi*	Rare (Ontario)
Y-Prickleback	*Allolumpenus hypochromus*	Rare (British Columbia)
Cultus Pygmy Coastrange Sculpin*	*Cottus aleuticus*	Threatened (British Columbia)
Spinynose Sculpin	*Asemichthys taylori*	Rare (British Columbia)
Pixy Poacher*	*Occella impi*	Rare (British Columbia)
Marine Mammals		
Sei Whale	*Balaenoptera borealis*	Rare (northwest Atlantic)
Minke Whale	*Balaenoptera acutorostrata*	Rare
Sperm Whale	*Physeter catadon*	NIAC
Atlantic White-sided Dolphin[1]	*Lagenorhynchus acutus*	?
Pacific White-sided Dolphin[1]	*Lagenorhynchus obliquidens*	?
Common Dolphin[1]	*Delphinus delphis*	?
Northern Right Whale Dolphin[1]	*Lissodelphis borealis*	?
Striped Dolphin[1]	*Stenella coeruleoalba*	?
Bottlenose Dolphin	*Tursiops truncatus*	?
Short-finned Pilot Whale	*Globicephela macrorhynchus*	Rare

*Endemic to Canada.

[1] Not of immediate concern.

TABLE 4. Definitions of conservation status as approved by COSEWIC April 1988.

SPECIES: "Species" means any species, subspecies, or geographically separate population.

VULNERABLE SPECIES: Any indigenous species of fauna or flora that is particularly at risk because of low or declining numbers, occurrence at the fringe of its range or in restricted areas, or for some other reason, but is not a threatened species.

THREATENED SPECIES: Any indigenous species of fauna or flora that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed.

ENDANGERED SPECIES: Any indigenous species of fauna or flora that is threatened with imminent extirpation or extinction throughout all or a significant portion of its Canadian range, owing to human action.

EXTIRPATED SPECIES: Any indigenous species of fauna or flora no longer existing in the wild in Canada but occurring elsewhere.

EXTINCT SPECIES: Any species of fauna or flora formerly indigenous to Canada but no longer existing anywhere.

In 1988 COSEWIC also reviewed the status of the marine invertebrate *Haliotis kamtschatkana* (Northern Abalone). Although the species was determined not to be in jeopardy in Canada, no status assignment was made as COSEWIC currently has no mandate for invertebrate species.

The 1988 general meeting was also noteworthy in that several changes in category definitions were adopted in order to clarify certain areas which had led to confusion in previous category assignments. The approved categories and their definitions are presented in Table 4 [*see* Cook and Muir (1984) for previous definitions]. Essentially, the new definitions involve little change from the previous wording except for the change in designation of the "rare" category to "vulnerable". This permits the inclusion of naturally rare species which are vulnerable because of their rarity and those species where declining numbers may indicate a potential threat. The use of "vulnerable" in status assignments will commence in 1989. Status assignments prior to and including April 1988 will remain as designated until such time that the status is reviewed again, on the basis of an updated report where necessary, and the status reaffirmed or redesignated as appropriate.

Concluding Remarks

The 12 reports included in the following series are reports on the status of the respective species in Canada. Status was assigned by consensus of the COSEWIC committee based on these reports, which are published under the name(s) of the original author(s). The reports have undergone minor editing to provide a brief introduction and some degree of consistency in format and presentation.

Acknowledgments

First and foremost are our thanks to the various authors who have so generously contributed their time and talents in support of COSEWIC and to the members of the subcommittee for their unstinting efforts in reviewing the reports and their helpful comments.

The subcommittee is grateful to World Wildlife Fund Canada, the Canadian Widlife Service and the National Museums of Canada for their assistance in the process. A special mention to Francis Cook and *The Canadian Field-Naturalist* for assistance in publication and editing and to all members of COSEWIC for their dedication and interest in the future of Canada's flora and fauna. Last, but not least, we gratefully acknowledge the financial and secretarial support provided through the Department of Fisheries and Oceans and the financial contribution of Fisheries and Oceans, Environment Canada, and World Wildlife Fund Canada, which has permitted the production of several new reports.

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Status of the Northern Abalone, *Haliotis kamtschatkana*, in Canada*

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Jamieson, G. S. 1989. Status of the Northern Abalone, *Haliotis kamtschatkana*, in Canada. Canadian Field-Naturalist 103(2): 153–158.

The Northern Abalone (*Haliotis kamtschatkana*) is the only abalone species in Canada and is widely distributed along the outer coast of British Columbia. It forms the basis for a small commercial fishery (47.2 t in 1986) and is harvested in the recreational fishery. Its distribution in commercial concentrations is patchy, and because of its cryptic behaviour on rocky bottoms, no total biomass estimates are available. Instead, stock status is monitered through regularly sampling sites, which have in the past supported abalone concentrations, in order to establish population recruitment trends. There is currently insufficient data to indicate the pattern of fluctuations in abundance over the long term, but it appears that the relatively high abundance of larger, older abalone, which was present prior to commercial fishery expansion in 1976, is unlikely to be re-established. Exploitation by the fishery, coupled with an anticipated increase in the distribution of Sea Otters (*Enhydra lutris*), a natural abalone predator in British Columbia, is expected to maintain future abalone population size at a moderate level.

L'ormeau pie (*Haliotis kamtschatkana*) est la seule espèce d'ormeau présente au Canada. On la rencontre tout le long de la côte de la Colombie-Britannique. Cette espèce fait l'objet d'une petite pêche commerciale (47,2 t en 1986) et d'une pêche récréative. La dispersion des concentrations exploitables commercialement et le comportement cryptique de cette espèce sur les fonds rocheux font que nous ne disposons d'aucune estimation de sa biomasse totale. L'état de ce stock est contrôlé par des prélèvements effectués régulièrement aux endroits où l'on a déjà noté des concentrations de ces animaux. Cela permet de déterminer les allures du recrutement de la population. Les données actuellement disponibles sont insuffisantes pour déterminer le régime des fluctuations de l'abondance à long terme, mais il semble peu probable que les concentrations relativement importantes d'ormeaux plus gros et plus âgés que l'on rencontrait avant l'expansion de la pêche commerciale de 1976 puissent être réétablies. L'exploitation due à la pêche et l'élargissement prévu de la distribution de la loutre de mer (*Enhydra lutris*), un prédateur naturel de l'ormeau en Colombie-Britannique, devraient avoir pour effet de maintenir les populations d'ormeaux à un niveau modéré.

Key Words: Northern Abalone, *Haliotis kamtschatkana*, British Columbia, distribution, stock status.

Ninety-five valid species occur in the family Haliotidae with nine species occurring along the west coast of North America (Cox 1962; Mottet 1978). Some are rarely observed because of scarcity or absence in shallow water, while others are sufficiently abundant to support commercial fisheries. The Northern, or Pinto Abalone *(Haliotis kamtschatkana)* (Jonas 1845), is the only species in British Columbia and is the basis for the Canadian commercial abalone fishery.

The species is moderately large with an elongate-oval, low shell with three to six open holes on tubular projections (Figure 1). Shell length is up to 150 mm (Quayle 1971), but most are in the range of 100 to 120 mm (Farlinger and Bates 1985). Although not as evident in Canadian specimens, Californian specimens have a broad channel present on the body whorl between the suture and row of holes, and the sculpture is of irregular lumps superimposed over a spiral sculpture of broad ribs with weak spiral ribs in the interspaces (McLean 1966). Canadian specimens generally have simply irregular lumps on a spiral sculpture. The external colour is mottled reddish or greenish with areas of white or blue. The muscle scar can be obvious but is lacking in California specimens (McLean 1966), and the shell interior is pearly white with a faint pinkish-green iridescence.

Distribution

The Northern Abalone is found from Sitka, Alaska (57°N), to Turtle Bay, Baja California (27.5°N; McLean 1966). In central California the typical form merges into the subspecies *H. kamtschatkana assimilis* Dall (Threaded Abalone), which occupies the southern part of the range (McLean 1966). *Haliotis kamtschatkana* had been thought to occur in northern Japan but

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*Accepted and reviewed by COSEWIC 12 April 1988. No status assigned — COSEWIC has no mandate for invertebrates.

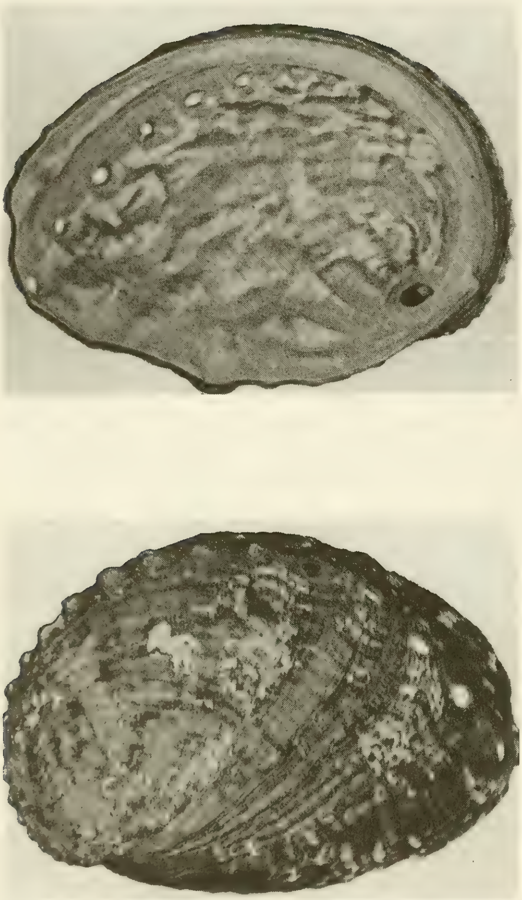

FIGURE 1. Northern Abalone, *Haliotis kamtschatkana* (from Cox 1962).

Ino (1951) suggested that the Japanese form is a northern subspecies of *Haliotis discus* Reeve, which he named *Haliotis discus hannai*, but this question has not yet been fully resolved.

The type locality for *Haliotis kamschatkana*, "near Unalaska, Kamchatka Sea", is evidently in error since there are no records of *Haliotis* occurring at any point along the Aleutian Islands (McLean 1966). However, specimens which may be *Haliotis kamtschatkana* have been collected from the Soviet Union, so the Kamchatka Sea may be correct (F. Bernard, Department of Fisheries and Oceans, Nanaimo, British Columbia, personal communication).

In the northern part of its range, the Northern Abalone may be found intertidally, while further south it occurs in deeper water. Keen and Coan (1974) report *Haliotis* as deep as 90 m. In British Columbia, it is most common at depths of 3 to 7 m (Mottet 1978), and fishing occurs wherever abalone are abundant (Figure 2). Northern Abalone prefer a firm substrate, usually rock, and are generally found in areas of moderate water exchange.

Protection

The species is afforded no special treatment in law although the provisions of the Fisheries Act do provide some measure of control with respect to recreational and commercial exploitation. Currently, there is a minimum legal size limit in both fisheries of 100-mm shell length, with an annual quota regulating landings in the commercial fishery. Since 1985, the quota has been 47.2 t. In the recreational fishery, there are daily catch limits per person, ranging from 12 north of Cape Caution (51° 10′N) to four in the southern part of Georgia Strait; the total annual harvest is unknown. The species may not be harvested using scuba gear.

Population Size and Trends

The Northern Abalone usually occurs in discrete concentrations throughout most of its range. Abalone are a preferred prey of Sea Otters (*Enhydra lutris*) (Ebert 1968), and it may be that the present level of abalone abundance has been influenced by the eradication of Sea Otters from the British Columbia coast in the late 1800s. In areas where Sea Otters have been re-introduced in California, almost all surviving abalone are found in rock crevices, while outside the range of Sea

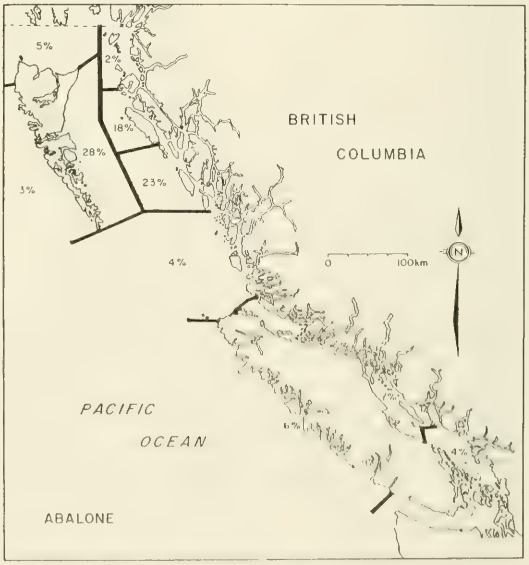

FIGURE 2. The percent distribution of commercial abalone landings taken from different regions of the coast in the period 1962–1984.

Otters, live abalone are larger in size and abundant outside crevices on open rock faces (Hines and Pearse 1982). Sea Otters have been re-introduced on the west coast of Vancouver Island and as their distribution spreads (MacAskie 1987), it can be expected that Northern Abalone abundance will be depressed to a lower level, as is the current situation in central California where Sea Otters are abundant (Bissell and Hubbard 1968).

Following the eradication of the Sea Otter in the nineteenth century and before the development and widespread use of underwater breathing equipment by commercial fishermen in the early 1970s, abalone mortality rate was probably reduced, causing their abundance to increase. Large, older abalone were particularly abundant (Quayle 1971). Intensive commercial exploitation began in 1976 (Figure 3) and although efforts were made to manage the fishery to a sustainable level of production, there were little data to indicate what the sustainable annual level of production might actually be (Breen 1980; Bernard 1982). Early landings were high and the abundance of legal-size abalone may have declined by as much as 80% by 1978 (Breen 1980). Annual production was initially assumed to be substantial because of the large initial biomass (Breen 1980), but recent data indicate that annual recruitment has been less than expected (Boutillier et al. 1984, 1985).

Abalone reach the legal size for exploitation at about six to eight years of age (Quayle 1971), and so it has only been in the last few years that the consequences of fishing on recruitment (entry rate of individuals into the legally exploited size range) could be investigated. Monitoring of recruitment began with the establishment of a fishery, and in the first decade following major exploitation, recruitment was low even though the abundance of adult animals was high at the time of spawning, since the current intensive fishery had not yet commenced. A lower adult abundance might have achieved a similar level of recruitment (Breen 1986), and so it is not clear at this time what effect the fishery has actually had on recruitment. Present management practices are to maintain a viable fishery in the hope that recruitment, which is perhaps most influenced by natural events, will increase in the future.

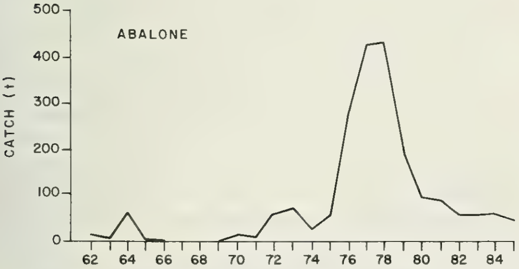

FIGURE 3. Annual landings (t) of abalone in British Columbia.

A problem common to establishing population size for animals which have limited mobility and are clumped in distribution is that abundance is both a function of density within a clump and the number and distribution of clumps. Because of the occurrence of abalone in rocky habitats, their cryptic behaviour and colouration, and their occurrence in often geographically remote areas, it has not been possible to determine accurately abalone population size (Bernard 1982).

Estimates of abundance have been made from available population density data (Breen 1980), but because this does not include data about the number and distribution of abalone concentrations, overall population abundance can not be satisfactorily measured. Current trends in population size are determined from sampling every few years at the same geographic locations which have in the past supported abalone concentrations. By sampling enough sites, scientists can monitor average year-class abundance and assess overall stock status. Recent data indicate that no substantial recruitment has occurred or seems imminent, and that while fishermen continue to find exploitable concentrations of abalone (Farlinger and Bates 1985), there is concern (Breen 1986) that even the current reduced fishery might be causing recruitment overfishing (*sensu* Cushing 1977).

Two management options exist based on the form of the accepted stock recruitment curve. If there is a poor relationship between stock abundance and recruitment rate, then yield-per-recruit should be maximized. This can be achieved with a high rate of fishing and a size limit perhaps slightly smaller than exists at present, i.e., 100 mm (Breen 1986). If a strong relationship exists, even though it may be obscured by subsequent environmental effects, then the strategy which would maximize yield-per-recruit might result in a very low egg production (Sluczanowski 1984) and hence reduce recruitment (Breen 1986).

As is the case with most exploited species, the stock recruitment relationship for Northern Abalone is unknown. Current management does not effectively regulate what proportion of the population is fished, since, while a quota exists, it is not a function of total biomass, and so there remains a risk that recruitment overfishing is occurring.

A poorly documented but probably substantial additional problem, particularly in the more heavily populated areas of the coast, is the poaching of abalone, i.e., the illegal harvesting of animals of sublegal size and/or not including landings in the quota restriction. Abalone command a high price per unit weight and in southern Vancouver Island in particular, poaching has been extensive, although it has apparently decreased in recent years because of successful enforcement and prosecution (R. Kehl, Department of Fisheries and Oceans, Victoria, British Columbia, personal communication).

Habitat

Abalone require a firm, stable substrate, usually rock but occasionally shell. Some water movement appears important, although on the exposed outer coast, some protection from direct ocean surge is required. Abalone may be found wherever such conditions may occur; they do not occur in areas of extreme exposure or in protected inside waters of higher temperature or low salinity. They are often found in association with the surface kelps, *Macrocystis integrifolia* and *Nereocystis leutkeanana*. The largest individuals and highest abundance are usually found in the upper subtidal zone, within 6 m of zero tide level. Their density does not seem to be related to food supply and, in fact, abalone are often least abundant where food seems most abundant and abundant where food seems scarce.

Abalone are herbivores (Mottet 1978) and as larger individuals, appear to most often feed on drifting kelp fragments. Consequently, abalone are often found concentrated near kelp beds. Newly settled abalone have been most frequently observed on the barren grounds caused by intensive grazing by sea urchins (Mottet 1978). Such areas often are abundant with encrusting red algae (*Lithothamnion* and related genera) and it appears these plants produce a chemical attractive to the settling abalone larvae. Such settlement is thus usually in water deeper than where adults are most abundant and as the young abalone become larger, they presumably migrate upwards toward the supply of drift material.

General Biology

Individual abalone are of only one sex and because fertilization is external to the animal, animals must spawn in synchrony with other individuals. Mass spawnings usually take place in summer and a large female may shed up to 2.3 million eggs (Breen 1986). The fertilized eggs hatch within a day, releasing a swimming larva, which drifts for 9 to 12 days in the plankton (Mottet 1978). Larvae then settle and if the substrate is suitable, survive and reach sexual maturity at about 50 mm shell length, or three years of age (Quayle 1971). Maximum age is estimated to be about 15 years (Quayle 1971). When abalone first start spawning, gonadal output is relatively small but this increases rapidly with increasing body size (Mottet 1978).

Abalone cannot be aged from shell measurements and so most growth data has been derived from tag returns. For animals between 60 and 80 mm shell length, the mean annual increment in size is about 6.5 mm (Quayle 1971). In areas where food is less abundant, growth appears to be stunted, and occassionally, high concentrations of such animals, called "surf abalone" by fishermen, can be found. Recent studies indicate that transplanting these animals to more suitable habitats can result in a high annual growth rate (Breen 1986; Emmet and Jamieson 1988), and this technique has been suggested both as a method of enhancing level of abalone reproduction in an area and as a way of allowing the commercial exploitation of individuals which would not otherwise reach the minimum legal size.

Although they periodically rest, abalone are often moving and are capable of travelling relatively rapidly, with some species moving up to 5 $m.min^{-1}$ (Mottet 1978). However, overall movement appears to be quite limited. Quayle (1971) reported that of the approximately 100 animals recovered after one year (5% of the almost 2000 tagged), none moved more than about 50 m from the release area.

Limiting Factors

Within the habitats known to support abalone, there are no base-line observations over a long time period to document fluctuations in abalone abundance. The rocky areas inhabited by abalone are not particularly subject to habitat loss, and while localized habitat destruction may result from an event such as an oil spill, this would be unlikely to have an impact on the overall coastal population.

Abalone populations may fluctuate considerably on an annual basis (Breen 1986), particularly at a local level (Quayle 1971), and this is compounded by a patchy larval settlement pattern. It now appears that the high abundance of older abalone, which characterized the population age structure at the beginning of the commercial fishery, is unlikely to recur so long as a fishery exists, but as indicated above, this might not have been a normal situation had Sea Otters been present. Their re-establishment on the coast in recent years will likely ensure that abalone abundance remains relatively low in their areas at least, and an anticipated allocation problem in the future will be between man and Sea Otters for abalone and other selected commercial invertebrate species (Bissell and Hubbard 1968).

Local abundance may also be affected by recreational fishermen using scuba gear. This type of fishing is difficult to monitor and control and the effects of such activity are not fully known, but the practice appears to be widespread and could be limiting populations in some locations.

Other predators of abalone are the Octopus (*Octopus dofleini*), Rock Crab (*Cancer productus*) and Sunflower Sea Star (*Pycnopodia helianthoides*) (Cox 1962; Mottet 1978). These predator species consume mostly other prey but they are capable of capturing and eating abalone if available. Mortality from such predation appears to occur at a low but steady rate (Emmet and Jamieson 1988).

There are ongoing efforts to culture Northern Abalone in British Columbia using hatcheries as a source of culture stock. One of the problems encountered in a hatchery on Vancouver Island was the occurrence of a thraustochytrid parasite (*Labyrinthuloides haliotidis* Bower) (Bower 1987a), which causes high mortality among juvenile abalone up to six months old (Bower 1987b). Larger juveniles and adults appeared to be resistent to the parasite. The distribution of this parasite, which had not been previously described, in the wild, is unknown.

Special Significance of the Species

The Northern Abalone has moderate commercial significance on the Pacific coast of Canada, and while the fishery is not currently large (landed value in 1985 was $442 000), it is important to those fishermen involved. Its continued well being is a regional fisheries management goal and abalone stock status is monitored at regular intervals to ensure that overfishing does not occur. Overall recruitment rate appears to be largely the result of natural events and while these are as yet largely unknown, continued monitoring in the future should help to elaborate them. The species is also of value to local residents and is subject to illegal harvest by recreational fishermen using scuba gear.

Evaluation

Although Northern Abalone significantly declined in abundance in the early years following expansion of the Canadian fishery, present indicators suggest that abundance may have stabilized. Routine monitoring reveals no recent population decline, and relative population abundance appears stable. However, there is the risk that recruitment overfishing is occurring, especially by illegal recreational fishing with the use of scuba gear, and while this might not affect species status over the short-term, it may effect the continuation of the fishery.

The existence of a fishery and the gradual spread in range of re-introduced Sea Otters will likely prevent the re-establishment of a high abundance of older, large abalone on a wide scale, such as characterized the British Columbia abalone population for most of this century. At present, considering the wide geograpic range of this species, Northern Abalone should be considered as not in any category of concern, but the status should be reviewed periodically due to the threat posed by illegal recreational fishing.

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Status of the Blackfin Cisco, *Coregonus nigripinnis*, in Canada*

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Parker, B. J. 1989. Status of the Blackfin Cisco, *Coregonus nigripinnis*, in Canada. Canadian Field–Naturalist 103(2): 159–162.

The Blackfin Cisco, *Coregonus nigripinnis* (Gill), is indigenous to the Great Lakes basin and has been reported from Lake Nipigon, and all the Great Lakes, except Lake Erie. Occurrence of the species in lakes Superior and Ontario was never confirmed. It is now extant only in Lake Nipigon. Little is known of its biology in Canadian or United States waters. *Coregonus nigripinnis* is not specifically protected in Canada, although general protection is afforded through the fish habitat sections of the Fisheries Act.

Le cisco à nageoires noires, *Coregonus nigripinnis* (Gill), est une espèce indigène du bassin des Grands lacs, dont la présence a été signalée dans le lac Nipigon et dans tous les Grands lacs sauf le lac Érié. Actuellement, cette espèce ne se trouve plus que dans le lac Nipigon, et l'on connaît mal sa biologie dans les eaux du Canada et des États-Unis. *Coregonus nigripinnis* ne fait pas l'objet d'une protection particulière au Canada, bien que les articles de la Loi sur les pêcheries qui ont trait à l'habitat du poisson le protègent d'une manière générale.

Key Words: Blackfin Cisco, *Coregonus nigripinnis*, ciscos, coregonids, chubs, lake herring, rare and endangered fishes, Ontario.

The Blackfin Cisco, *Coregonus nigripinnis* (Gill), is one of the largest of the deepwater ciscos and has a slender, compressed body with an average length of 33 cm. Adults weigh up to 1 kg, although some few individuals may be slightly longer and heavier (Figure 1). The head is triangular in shape and the eyes large. The lower jaw usually projects beyond the upper jaw, but is sometimes the same length. The overall coloration is silvery with a pink or purple iridescence. The back is dark green or black, shading to silver on the sides and ventral surface. Most individuals show light pigmentation on the jaws. Nuptial tubercles may be found on breeding males. All fins are typically black, giving rise to the name for this species.

Distribution

The Blackfin Cisco has been reported from all of the Great Lakes except Lake Erie, and has also been reported from Lake Nipigon (Figure 2). It is now believed to be extirpated in Lake Michigan, and probably extirpated in Lake Huron (Clarke and Todd 1980; McAllister et al. 1985). Apparently, *Coregonus nigripinnis* is now extant only in Lake Nipigon (Clarke and Todd 1980; R. Borecky. Ontario Ministry of Natural Resources (OMNR), Lake Nipigon Fisheries Assessment Unit, Beardmore, Ontario, personal communication). Its occurrence in lakes Superior and Ontario has not been confirmed (Clarke and Todd 1980).

The systematics of this species within the Great Lakes is unclear. Koelz (1929) recognized four subspecies, each restricted to various lakes: *Coregonus nigripinnis nigripinnis* (from lakes Michigan and Huron), *Coregonus nigripinnis regalis* (Lake Nipigon), *Coregonus nigripinnis cyanopterus* (Lake Superior), and *Coregonus nigripinnis prognathus* (Lake Ontario). However, Clarke and Todd (1980) report that *Coregonus nigripinnis cyanopterus* in Lake Superior, may be synonymous with *Coregonus zenithicus*, as may be *Coregonus nigripinnis prognathus* in Lake Ontario. Clarke and Todd do not consider *Coregonus nigripinnis* ever to have occurred in Lake Superior or Lake Ontario. Additionally, they consider *Coregonus nigripinnis* populations reported from outside the Great Lakes basin to be *Coregonus artedii*. T. Todd (Great Lakes Fisheries Laboratory, Ann Arbor, Michigan, personal communication) indicated that intermediate morphotypes between these species are common and doubts the distinction of Lake Herring (*Coregonus artedii*) and the Blackfin Cisco. The American Fisheries Society (1980) lists them as distinct species.

Protection

No specific legal protection exists for *Coregonus nigripinnis* in Canada. Miller (1972) reports this species as threatened in Wisconsin, but it is now considered extinct (in state waters) and is no longer

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*Threatened status assigned by COSEWIC April 1988.

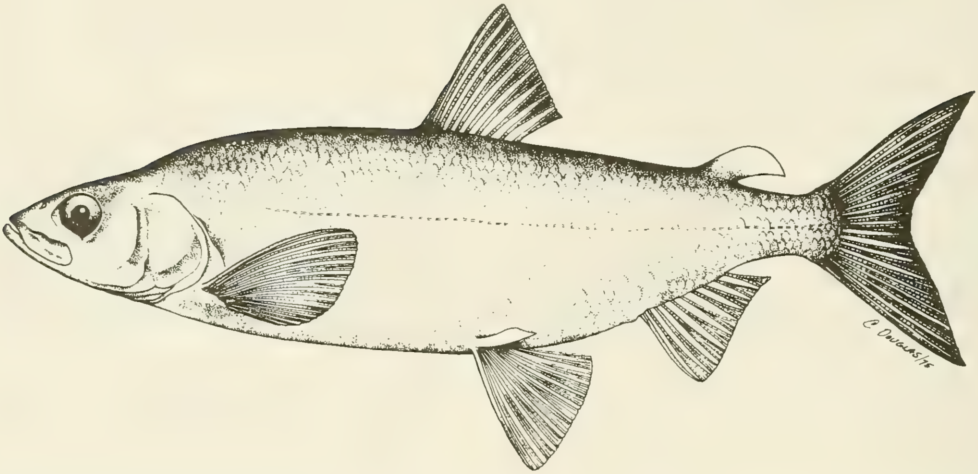

FIGURE 1. Blackfin Cisco, *Coregonus nigripinnis*. (Drawing by C. E. Douglas, courtesy D. E. McAllister, National Museum of Natural Sciences.)

protected (B. Swanson, Wisconsin Department of Natural Resources, Bayfield, Wisconsin, personal communication). *Coregonus nigripinnis* is listed as endangered by the State of Michigan (Endangered Species List, February 1983 — pursuant to Public Act Number 203) and is legally protected from collection. However, the United States Fish and Wildlife Service (USFWS) has listed the species as extinct (J. Engel, USFWS, Division of Endangered Species, Minneapolis, Minnesota, personal communication). The State of Michigan is now considering removing the species from the State Endangered Species List (S. Taylor, Michigan Department of Natural Resources, Lansing, Michigan, personal communication). Illinois, Indiana, Wisconsin, Minnesota and New York consider *Coregonus nigripinnis* to be extinct (in state waters) and is therefore not legally protected in these jurisdictions.

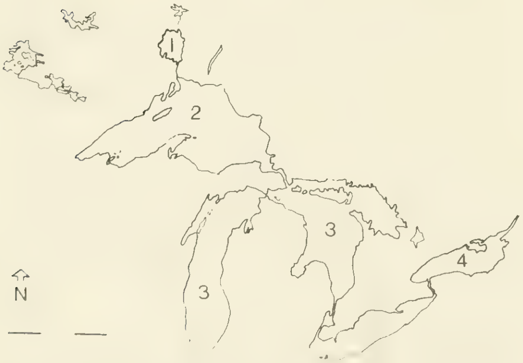

FIGURE 2. Distribution of the Blackfin Cisco, *Coregonus nigripinnis*: (1) Extant (Clarke and Todd 1980); (2) Reported by Koelz (1929) as *Coregonus nigripinnis cyanopterus*. Clarke and Todd (1980) consider there to be no valid records for Lake Superior; (3) Extirpated (Clarke and Todd 1980); (4) Reported by Koelz (1929) as *Coregonus nigripinnis prognathus*. Clarke and Todd (1980) consider there to be no valid record for Lake Ontario.

Commercial harvest quotas or effort restrictions for deepwater ciscos as a group are in effect in Illinois (R. Hess, Illinois Department of Conservation, Zion, Illinois, personal communication) and have recently (1984) been instituted for the Ontario waters of lakes Superior and Huron (R. Payne, OMNR Lake Huron Fisheries Assessment Unit, Owen Sound, Ontario; W. MacCullum, OMNR Lake Superior Fisheries Assessment Unit, Thunder Bay, Ontario, personal communication). The deepwater cisco fisheries in Michigan waters of lakes Huron and Michigan have been closed (A. Wright, Michigan Department of Natural Resources, Lansing, Michigan, personal communication). No harvest quotas for cisco have been implemented in Lake Nipigon.

Population Sizes and Trends

Coregonus nigripinnis was formerly abundant in Lake Michigan (Koelz 1929). Smith (1964) reports that intense exploitation by the commercial fishery during the 1800s through to the early 1900s and Sea Lamprey (*Petromyzon marinus*) predation resulted in a drastic reduction in abundance by the 1930s. This species constituted less than 1% of the 1930 to 1931 catch of deepwater ciscos taken during experimental fishing in Lake

Michigan (Smith 1964). *Coregonus nigripinnis* was absent from areas of former abundance in experimental index surveys made during 1954 to 1955 and 1960 to 1961 (Smith 1964). Moffet (1957) reported the species near extinction by 1956. The last record from Lake Michigan is from 1969 (Clarke and Todd 1980).

Index fishing and sampling of the commercial catch from Lake Michigan in Illinois (R. Hess, personal communication), Indiana (B. Koch, Indiana Department of Natural Resources, Michigan City, Indiana, personal communication), Wisconsin (L. Kernan, Wisconsin Department of Renewable Resources, Madison, Wisconsin; personal communication), and Michigan (A. Wright, personal communication) have not produced any further specimens.

Specific information regarding population size and trends of *Coregonus nigripinnis* in lakes Huron and Nipigon is very limited. Berst and Spangler (1972) state that the larger species of deepwater cisco (which would include *Coregonus nigripinnis*) had been selectively removed from Lake Huron by the 1940s as a result of Sea Lamprey predation and the commercial harvest, as was the case in Lake Michigan. Two *Coregonus nigripinnis* specimens were collected in Canadian waters of Lake Huron (44° 29′ N, 81° 53′W) in 1960 (NMC *60-493A*). No specimens have been collected since and this species is now considered extirpated from Lake Huron (R. Payne, personal communication). The penultimate record of this species from Lake Nipigon is from 1974 (Lankester and Smith 1979). The species is considered extant in the lake (Clarke and Todd 1980) and populations are thought to be "probably stable" (R. Borecky, personal communication).

The most recent record from Lake Nipigon is from 1986 (E. Holm, Royal Ontario Museum, Toronto, Ontario, personal communication). Several Blackfin Cisco were reported from the northern end of the lake; they were captured along with a number of Lake Herring (*Coregonus artedii*) in the Little Jackfish River during a spawning run (Ontario Hydro 1988). The apparent similar spawning location and timing, at least in this river, suggest the probable reason for encountering many intergrades between the two species and again reiterates the concern that *Coregonus nigripinnis* may not be distinct from *Coregonus artedii*. On the other hand, decreasing numbers may be leading to introgressive hybridization with the Lake Herring as suggested by Smith (1964) and hastening the final demise of the species here as well.

Habitat

Information on the habitat of *Coregonus nigripinnis* is meagre. This species was taken at depths of 183 m in Lake Huron (Koelz 1929). Clarke and Todd (1980) report that this species occurred at depths of 90 to 160 m in lakes Michigan and Huron. Dymond (1926) reports that in Lake Nipigon *Coregonus nigripinnis* was captured at depths down to 104 m, but in summer it was common at shallower depths (37 m). Data collected in 1986 indicate that at least some fish are adapted to much shallower depths and may be taken in shallow riverine environments in the summer and fall (Ontario Hydro 1988).

General Biology

Reproductive/Capability: Breeding age, breeding frequency, fecundity, early life history, age/sex ratio, and population structure are unknown for this species. *Coregonus nigripinnis* apparently spawns from October to January (Koelz 1929). Age/length/weight relationships are not known for Great Lakes populations. Adults range in length from 230 to 370 mm standard length (Clarke and Todd 1980). McAllister et al. (1985) report a maximum total length of 510 mm.

The growth potential of the Lake Nipigon population and remnant Great Lakes populations, if existing, is unknown.

Species/Movement: Virtually nothing has been reported for this species regarding seasonal or spawning migrations. Spawning areas have not been documented in the literature. Ripe specimens collected from the Little Jackfish River in October were believed to spawn in the river (Ontario Hydro 1988).

Dymond (1926) reported that in Lake Nipigon, depth distribution ranged to 104 m, but noted that in summer, *Coregonus nigripinnis* occurred in numbers at a depth of 37 m, suggesting a seasonal movement from deep to shallower waters.

No other information is available regarding breeding or wintering ranges.

Behaviour/Adaptability: An assessment of the degree of tolerance of this species to human disturbance is difficult because human interference, where documented, has been of a dramatic nature. The intense exploitation of *Coregonus nigripinnis* by the commercial fisheries in the early 1900s led to the extinction or extirpation of populations in the Great Lakes (Smith 1964; Berst and Spangler 1972; Christie 1972; Lawrie and Rahrer 1972).

Coregonus nigripinnis apparently feeds almost exclusively on *Mysis relicta* (Scott and Crossman 1973). Information is too meagre to establish the degree of specialization of this species in relation to habitat and breeding sites.

Limiting Factors

Factors known to have caused the decline of *Coregonus nigripinnis* in the Great Lakes were the overexploitation by the commercial fisheries and Sea Lamprey predation (Smith 1964; Berst and

Spangler 1972; Lawrie and Rahrer 1972; Christie 1973). Smith (1964) suggests that in Lake Michigan the extirpation of the last *Coregonus nigripinnis* may have been through introgressive hybridization with *Coregonus artedii*. Similar circumstances may have led to the demise of other deepwater ciscos such as the Longjaw Cisco, *Coregonus alpenae* (*see* Campbell 1987).

Rainbow Smelt (*Osmerus mordax*) and Alewife (*Alosa pseudoharengus*) compete for food with deepwater cisco populations in lakes Huron and Ontario (Berst and Spangler 1972; Christie 1972) and along with continued Sea Lamprey predation may in part be suppressing resurgence of remnant deepwater cisco populations in the Great Lakes.

Special Significnace of the Species

Coregonus nigripinnis was commercially important in the past, and as part of the deepwater community this species would have formed part of the traditional forage base for Lake Trout (*Salvelinus namaycush*) populations in the Great Lakes.

Evaluation

The following factors were used in the evaluation of the status of the Blackfin Cisco in Canada: (1) the species is endemic to the Great Lakes; (2) it is extirpated from much of its former range and is now only found in Lake Nipigon where the population is still exposed to fishing pressure; (3) seven species of deepwater cisco are recognized, five of which have greatly reduced ranges and populations (two are extinct); (4) the population structure and ecology of the remaining population are not known; (5) the demise of species in other parts of the range was related, at least in part, to exploitation by the commercial fishery; (6) no protection is currently afforded to the only known population remaining.

Based on the information evaluated, it is recommended that the Blackfin Cisco be regarded as a threatened species in Canada.

Acknowledgments

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Status of the Bloater, *Coregonus hoyi*, in Canada*

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Parker, B. J. 1989. Status of the Bloater, *Coregonus hoyi*, in Canada. Canadian Field-Naturalist 103(2): 163–167.

The Bloater (*Coregonus hoyi*) is indigenous to the Great Lakes basin of North America. All populations previously reported are currently extant, except in Lake Nipigon, where the species is considered probably extirpated. The species is common in Canadian waters of lakes Huron and Superior, but rare in Lake Ontario. The biology of this species in Canadian waters is not well known.

Le cisco de fumage (*Coregonus hoyi*) est une espèce indigène du bassin des Grands lacs de l'Amérique du nord. Toutes les populations qui ont déjà fait l'objet des rapports existent encore, sauf celle du lac Nipigon que l'on considère comme probablement déracinée et rare dans lac Ontario. Cette espèce est commune dans les parties des lacs Huron et Supérieur qui relèvent du Canada mais l'on connaît mal sa biologie dans les eaux canadiennes.

Key Words: Bloater, *Coregonus hoyi*, coregonids, chubs, lake herrings, Great Lakes, Ontario.

The Bloater, *Coregonus hoyi* (Gill), is the smallest of the endemic deepwater ciscos. The body is elongated (Figure 1) and laterally compressed. The average adult length is 20 to 25 cm but varies from lake to lake, fish from lakes Michigan and Ontario usually being longer (Scott and Crossman 1973). They are generally silver in colour with some pink or purple iridescence in live specimens and a green tint above the lateral line. There may be some weak pigmentation on the head, lower jaws and fins (Scott and Crossman 1973).

The species was generally overlooked in the early years of the chub fishery of the Great Lakes, but as the larger deepwater species were fished out they became increasingly more important.

Distribution

The Bloater is indigenous to the Great Lakes basin (Figure 2), and has been recorded from Lake Nipigon and all of the Great Lakes except Lake Erie (Dymond 1926; Koelz 1929). Clarke and Todd (1980) consider it probably extirpated from lakes Nipigon and Ontario.

Clarke and Todd (1980) report that *Coregonus hoyi* populations from outside the Great Lakes drainage were misidentified *Coregonus artedii*, Lake Herring, or *Coregonus zenithicus*, Shortjaw Cisco.

Protection

No specific legal protection exists for this species in Canada or the United States.

Indirect protection of populations in United States waters is afforded through commercial catch quotas or fishing effort restrictions in Lake Superior (J. Peck, J. Spurrier, Michigan Department of Renewable Resources, Marquette, Michigan; B. Swanson, Wisconsin Department of Natural Resources, Bayfield, Wisconsin, personal communications) and Lake Michigan (Brown et al. 1985).

The deepwater cisco fishery in Michigan waters of Lake Huron has been closed since 1970 (A. Wright, Michigan Department of Natural Resources, Lansing, Michigan, personal communication). Recently (1984), quota restrictions on the commercial harvest of deepwater ciscos have been instituted for Canadian waters (R. Payne, Ontario Ministry of Natural Resources (OMNR) Lake Huron Fisheries Assessment Unit, Owen Sound, Ontario; W. MacCallum, OMNR Lake Superior Fisheries Assessment Unit, Thunder Bay, Ontario, personal communications).

Population Size and Trend

Originally widespread and abundant in Lake Ontario (Koelz 1929; Pritchard 1931; Stone 1944), Bloater stocks declined dramatically in Lake Ontario from the 1940s through the 1960s in response to overexploitation and possible competition for food from Smelt, *Osmerus mordax* (Christie 1972). The most recent specimen was collected in 1982 off Oswego, New York, by the United States Fish and Wildlife Service (T. Todd, U.S. Fish and Wildlife Service, Ann Arbor, Michigan, personal communication); the last previously known occurrence was a specimen collected off Port Credit, Ontario (43°33′N, 79°35′W), in 1972 (Todd 1978). Clarke and Todd

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*Reviewed by COSEWIC and determined not to be in jeopardy in Canada (not in any COSEWIC category) April 1988.

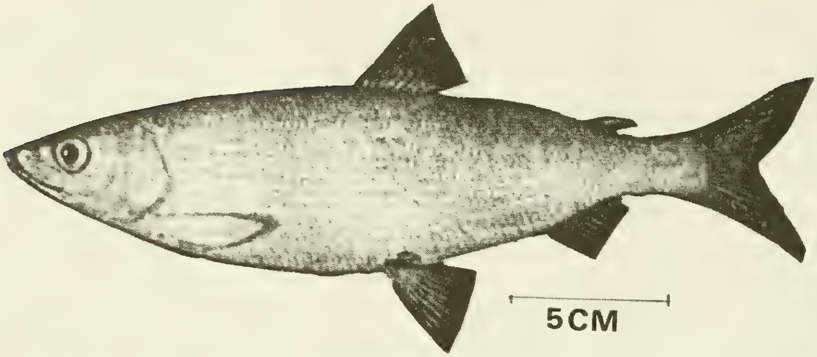

FIGURE 1. Bloater, *Coregonus hoyi* (*from* Todd 1980, by permission).

(1980) had considered the species probably extirpated in Lake Ontario, but the 1982 record indicates the population may still be present.

Coregonus hoyi populations increased dramatically in Lake Michigan during the 1940s and 1950s following a decline in predators and larger deepwater cisco competitors (Moffet 1957; Smith 1964). Subsequent overexploitation and recruitment failure resulting from a highly unbalanced sex ratio (female-biased), led to a dramatic decline in abundance by 1976, when the fishery for deepwater cisco was closed (Brown 1970; Wells and McLain 1973; Holey 1983). Populations have since rebounded and limited quota fisheries have been reopened in Wisconsin (Holey 1983), Michigan (A. Wright, personal communication), and Illinois (R. Hess, Illinois Department of Conservation, Zion, Illinois, personal communication) waters of Lake Michigan. *Coregonus hoyi* now constitutes from 90 to 99% of the commercial catches of deepwater ciscoes in these jurisdictions.

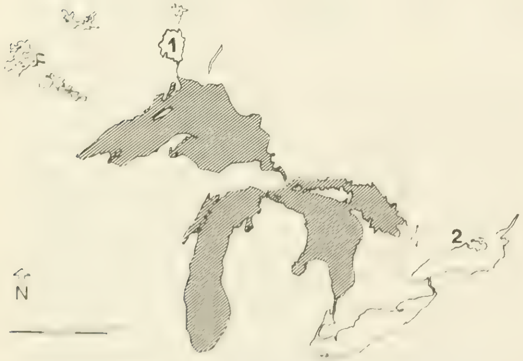

FIGURE 2. Distribution of the Bloater, *Coregonus hoyi*: (1) Probably extirpated (Clarke and Todd 1980); (2) Rare (Clarke and Todd 1980). In hatched area it is common to abundant (Todd 1978, 1980).

In Lake Superior, Bloater stocks increased during the 1950s and 1960s from historic levels of abundance in response to decreased predation by Lake Trout (*Salvelinus namaycush*) and reduced competition from larger deepwater ciscos (Lawrie and Rahrer 1972; Peck 1975; Pratt 1980). Populations in U.S. waters appear to have been decreasing since 1970 (Peck 1975, 1977; Pratt 1980). R. Cullis (OMNR, Thunder Bay, Ontario, personal communication) indicates that chubs are common in some areas of Lake Superior and are commercially harvested.

No size or trend information is available for the Bloater population in Lake Nipigon. This species was reported as common in the lake by Koelz (1929), but was not taken by OMNR in collections of deepwater ciscos made in 1973 (R. Borecky, OMNR Lake Nipigon Fisheries Assessment Unit, Beardmore, Ontario, personal communication) and has not been identified from more recent collections (B. Ritchie, personal communication, 1988).

Bloater populations in Lake Huron declined during the 1960s due to overexploitation and possible recruitment failure resulting from a highly unbalanced, female-biased sex ratio (Smith 1970; Berst and Spangler 1972). Assessment of population levels in the lake indicates the species has become re-established and it is fished commercially at present in Lake Huron (Ebner et al. 1984; R. Payne, personal communication).

Habitat

Koelz (1929) reports *Coregonus hoyi* prefer depths of greater than 55 m, but its depth distribution in the Great Lakes has been reported to range from 9 to 177 m with concentrations observed at various depths (Pritchard 1931; Jobes 1943; Dryer 1966; Smith 1970; Peck 1975, 1977). Its occurrence has been reported as widespread at preferred depths (Koelz 1929, Pritchard 1931, Smith

1964). Dymond (1926) reported this species to occur from 17 to 101 m in Lake Nipigon. Jobes (1949) reported that in Lake Michigan, *Coregonus hoyi* were most abundant from 37 to 108 m where water temperatures ranged from 3.8 to 7.0°C. Edsall et al. (1970) noted that adults in Lake Michigan were captured most frequently on the bottom in late summer at water temperatures of 8 to 10°C.

In Lake Michigan, Crowder and Magnuson (1982) reported *Coregonus hoyi* to occur pelagically, concentrating at depths where water temperatures ranged from 5 to 16°C. These authors report an ultimate upper-lethal temperature of 26 to 27°C for adult Bloaters. Wells (1966) reported that in Lake Michigan Bloaters were most abundant near the bottom at 91 to 110 m, where water temperatures were less than 4.7°C, but were also captured at depths as shallow as 18 to 37 m.

The available information outlined above suggests the habitat requirements of the Bloater are not greatly specialized. Diet information suggests this species can be benthic or pelagic (Wells and Beeton 1963; Dryer and Beil 1968; Janssen 1978; Crowder and Binkowski 1983).

General Biology

Reproductive Capability: Spawning has been reported to occur from January through March in Lake Michigan (Koelz 1929; Emery and Brown 1978). In Lake Superior peak spawning was reported from February to March, but some spawning is thought to occur throughout the year (Dryer and Beil 1968). Spawning in Lake Ontario was reported by Koelz (1929) to have occurred from November to March.

Age at maturity for *Coregonus hoyi* is reported as 2+ to 3+, which corresponded to total lengths of 150 to 180 mm (Pritchard 1931; Dryer and Beil 1968). Females are longer lived than males, attaining ages of 10+ to 11+, compared to 9+ to 10+ for males (Stone 1944; Dryer and Beil 1968). Breeding frequency is unknown. Fecundity is reported to range from 1387 to 34 891 eggs at total lengths of 183 mm and 337 mm, respectively (Bruch 1982). Other reported fecundity data are similar (Dryer and Beil 1968; Auer 1982). The egg and larval stages have been described by Auer (1982).

Age/sex ratios are known to have fluctuated widely in the past for Lake Michigan and Lake Huron populations (Brown 1970; Smith 1970). Holey (1983) detailed age structure of the Lake Michigan population in recent years. Pratt (1980) reports that in Wisconsin waters of Lake Superior the sex ratio ranged from 41 to 50% males in 1979 and that the commercial catch was dominated by age groups 5 to 8. The population of *Coregonus hoyi* in Michigan waters of Lake Huron has become re-established and is currently dominated by age groups 3 and 5 (Brown et al. 1985). Clarke and Todd (1980) report adult size as 200 to 300 mm standard length.

Reproductive success and mortality rates have not been extensively studied for this species. Commercial fishery assessment has documented variable year-class strength for stocks in lakes Superior (Pratt 1980), Michigan (Holey 1983) and Huron (R. Payne, personal communication) in recent years.

Species Movement: Dryer (1966) stated that this species migrates inshore to depths of less than 55 m during the summer and fall.

Behaviour/Adaptability: Overexploitation is known to have been partly responsible for the collapse of stocks in Lake Ontario and in Lake Michigan during the early 1970s (Christie 1972; Holey 1983; Brown et al. 1985). Stocks in Lake Michigan appear to be stable or increasing under current limited-quota commercial fisheries (Holey 1983). The impact of other human activity has not been reported.

The degree of habitat specialization of this species does not appear great, other than the depth and water temperature preferences noted earlier. Breeding sites have not been well documented, but Dryer and Beil (1968) report that spawning in Lake Superior occurred at a depth of 37 to 91 m over varied bottom types, suggesting no stringent requirements. Diet analysis indicate that *Coregonus hoyi* is largely a pelagic feeder utilizing *Mysis relicta*, *Pontoporeia hoyi*, and copepods in varying proportions (Koelz 1929; Pritchard 1931; Wells and Beeton 1963; Dryer and Beil 1968; Crowder and Binkowski 1983).

The recent resurgence of Bloater populations in Lake Michigan following closure of the commercial fisheries (Holey 1983) and the shift to Bloater dominance in the deepwater cisco communities in lakes Michigan and Superior (Peck 1975, 1977; Pratt 1980; Holey 1983; Brown et al. 1985) both suggest *Coregonus hoyi* may respond readily to management and ecological change.

Limiting Factors

Colby et al. (1972) suggested that eutrophication in Lake Ontario may be preventing a resurgence of the deepwater cisco community, possibly by interfering with reproduction. Competition for food and thermal space by Smelt and Alewife (*Alosa pseudoharengus*) and predation by Sea Lamprey (*Petromyzon marinus*) have also been suggested as factors possibly contributing to the decline and/or re-establishment of cisco populations in the Great Lakes (Smith 1964, 1970; Berst and Spangler 1972; Christie 1972; Crowder and Binkowski 1983).

Special Significance of the Species

The Bloater was, and in some areas continues to be, an important commercial species. Historically, it also formed part of the forage base for native Lake Trout.

Coregonus hoyi is endemic to the Great Lakes drainage. Todd (1978) considers the species now abundant or common in all the Great Lakes where it occurred, except lakes Ontario and Nipigon where it evidently is rare. Other related forms of the subgenus *Leucicthys*, also endemic to the Great Lakes, are now extirpated from much of their ranges or are now rare.

Evaluation

The following factors were used in the evaluation of the status of the bloater in Canada: (1) the species is endemic to the Great Lakes; (2) it is common in lakes Superior, Huron and Michigan and rare in Lake Ontario and possibly Lake Nipigon; (3) seven species of deepwater cisco are recognized, five of which have greatly reduced ranges and populations; (4) it is commercially harvested in Canadian waters.

Based on the information evaluated, it is recommended that the bloater not be considered in jeopardy in Canada and not be included in COSEWIC's listing of rare, threatened or endangered species.

Acknowledgments

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I thank the staff of the Ontario Ministry of Natural Resources and members of various state agencies for supplying personal input and data summaries. I also greatly appreciate the assistance of D. E. McAllister, National Museum of Natural Sciences, and E. J. Crossman, Royal Ontario Museum, in providing access to museum records. A special thanks to T. Todd of the U.S. Fish and Wildlife Service for his helpful comments and review of the report.

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Status of the Deepwater Cisco, *Coregonus johannae*, in Canada*

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29 Golden Drive, Barrie, Ontario L4M 4S5

Parker, B. J. 1989. Status of the Deepwater Cisco, *Coregonus johannae*, in Canada. Canadian Field-Naturalist 103(2): 168–170.

The Deepwater Cisco, *Coregonus johannae* (Wagner), was indigenous to the Great Lakes basin, and historically occurred in lakes Huron and Michigan. It is now considered extinct in Lake Michigan and Lake Huron. Little is known of its biology in Canadian or United States waters.

Le cisco de profondeur, *Coregonus johannae* (Wagner), était une espèce indigène du bassin des Grands lacs où il peuplait anciennement les lacs Huron et Michigan; l'espèce est maintenant considérée éteinte dans ces deux lacs. On connaît mal sa biologie dans les eaux canadiennes et américaines.

Key Words: Deepwater Cisco, *Coregonus johannae*, coregonids, chubs, ciscos, lake herrings, extinct species, Ontario.

The Deepwater Cisco, *Coregonus johannae* (Wagner), was the largest of the Great Lake ciscos and had an elongate, moderately compressed body with an average length of 29 cm and an average adult weight of about 0.7 kg, although some few individuals may have been longer and heavier (Figure 1). The head was long and narrow, and the eyes moderate. This fish was rarely caught at depths shallower than 14 m and was known to inhabit waters at a depth of 180 m or more. The overall colouration was silvery with a pink or purple iridescence. The back was green or blue, the sides blue-green and the ventral surface silvery white. Some individuals showed light pigmentation on the fins. Nuptial tubercles could be found on breeding males (*see* Scott and Crossman 1973).

Distribution

The Deepwater Cisco was indigenous to the Great Lakes basin and occurred only in lakes Michigan and Huron (Figure 2). It is now considered almost certainly extinct in Lake Michigan (Smith 1964; Todd 1980) and in Lake Huron (McAllister et al. 1985; A. Wright, Michigan Department of Renewable Resources, Lansing, Michigan; R. Payne, Ontario Ministry of Natural Resources, Lake Huron Fisheries Assessment Unit, Owen Sound, Ontario; personal communications).

Protection

No specific legal protection exists for this species in Canada. This species is considered extinct in the United States (by both federal and state governments) and is therefore, not legally protected.

Commercial harvest quotas for deepwater cisco as a group are in effect in Illinois (R. Hess, Illinois Department of Conservation, Zion, Illinois, personal communication) and the Wisconsin waters of Lake Michigan (L. Kernan, Wisconsin Department of Natural Resources, Madison, Wisconsin, personal communication). The deepwater cisco fishery in Michigan waters of Lake Huron is closed and is also closed in much of the Michigan waters of Lake Michigan (A. Wright, personal communication). Harvest quotas were also instituted for the group in Canadian waters of Lake Huron in 1984 (R. Payne, personal communication).

Population Size and Trend

Coregonus johannae was once abundant in Lake Michigan, and along with *Coregonus nigripinnis* supported the pre-1900s deepwater cisco fishery (Moffet 1957; Smith 1964). Intense commercial exploitation had drastically reduced the numbers of *Coregonus johannae* by 1930 to 1932 (Smith 1964). Sea Lamprey (*Petromyzon marinus*) predation during the 1940s was also believed by Smith to have contributed to the final collapse of populations in Lake Michigan.

The last record of *Coregonus johannae* in Lake Michigan was from 1951 (Moffet 1957). Experimental netting during 1954 to 1955 and 1960 to 1961 at sites where this species formerly occurred produced no further specimens (Smith 1964). Index fishing and inspection of the commercial fish catch in the states of Michigan (A. Wright, personal communication), Illinois (R. Hess, personal communication), Indiana (B. Koch, personal communication), and Wisconsin (L.

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*Extinct status assigned by COSEWIC — April 1988.

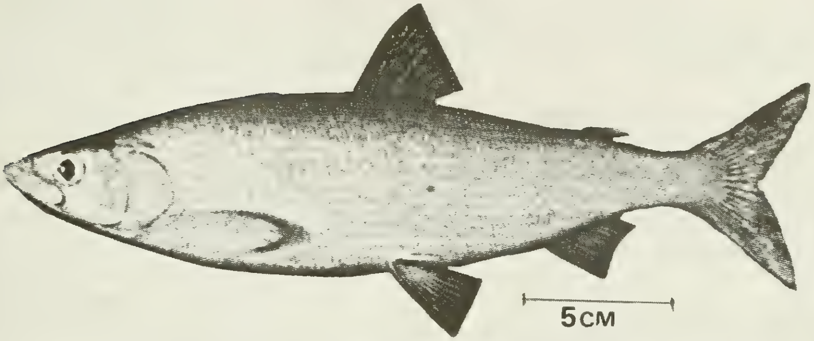

FIGURE 1. Deepwater Cisco, *Coregonus johannae* (*from* Todd 1980, by permission).

Kernan, personal communication) also failed to produce any authenticated specimens of *Coregonus johannae* from United States waters.

Published information dealing specifically with *Coregonus johannae* populations in Lake Huron is lacking. Berst and Spangler (1972) state that the larger species of deepwater ciscos (which would include *Coregonus johannae*) had been selectively removed from Lake Huron by the 1940s as a result of Sea Lamprey predation and commercial fishing, as was the case in Lake Michigan. The last specimen recorded from Canadian waters of Lake Huron was in 1952 (ROM *19214*). *Coregonus johannae* is now considered extinct in Canadian waters of Lake Huron (R. Payne, personal communication).

Habitat

Little is known of the habitat of *Coregonus johannae*. Capture data indicate the depth distribution of this species ranges between 29 and 143 m (Koelz 1929). Koelz also reported this species was rarely caught at depths of less than 64 m, and maximum abundance occurred between 91 and 143 m. Todd (1980) reports a depth range of 50 to 160 m.

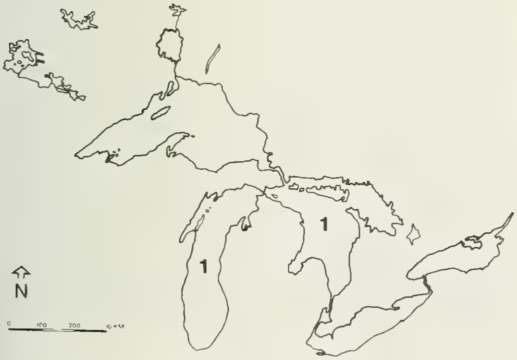

FIGURE 2. Former distribution of the Deepwater Cisco, *Coregonus johannae*: (1) Extinct — lakes Michigan and Huron (R. Payne, personal communication; Todd 1980).

General Biology

Reproductive Capability: Information on reproductive characteristics of *Coregonus johannae* is scarce. Koelz (1929) reported that specimens smaller than 165 mm were not mature and that most specimens 195 mm in length were mature. Todd (1980) reports adult size from 250 to 300 mm standard length (SL).

Breeding age, fecundity and spawning interval are unknown. Koelz (1929) reported that spawning occurs during August and September and suggested that some females may spawn every second year.

Species Movement: No information is available.

Behaviour/Adaptability: An assessment of the degree of tolerance of this species to human disturbance is difficult because human interference, where documented, has been of a dramatic nature. The intense exploitation of *Coregonus johannae* by the commercial fishery led to its extirpation in Lake Michigan (Smith 1964) and probably also in Lake Huron (Berst and Spangler 1972).

Coregonus johannae appear to feed on *Mysis relicta*, Fingernail Clams (*Pisidium*) and aquatic insects (Scott and Crossman 1973). Other than an apparent depth preference, nothing is known regarding the degree of specialization of this species in relation to habitat and breeding sites.

Limiting Factors

Overexploitation by the commercial fishery and lamprey predation were the causes of the collapse of this species in Lake Michigan (Moffet 1957; Smith 1964) and probably in Lake Huron (Berst and Spangler 1972). Smith (1964) suggests that in

Lake Michigan the extinction of the last *Coregonus johannae* may have come through introgressive hybridization.

Special Significance of the Species

Coregonus johannae was commercially important in the past and, as part of the deepwater cisco community, would have formed part of the traditional forage base for Lake Trout (*Salvelinus namaycush*) and Burbot (*Lota lota*) (Smith 1964).

Evaluation

The following factors were used in the evaluation of the status of the Deepwater Cisco: (1) the species is endemic to the Great Lakes; (2) it is extinct within its entire range in lakes Michigan and Huron, where the last specimens were collected in the early 1950s despite specific sampling of habitat in recent years.

Based on the information evaluated, it is recommended that the Deepwater Cisco be classified as extinct in Canada.

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Status of the Kiyi, *Coregonus kiyi*, in Canada*

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Parker, B. J. 1989. Status of the Kiyi, *Coregonus kiyi*, in Canada. Canadian Field-Naturalist 103(2): 171–174.

The Kiyi, *Coregonus kiyi*, is indigenous to the Great Lakes basin and has been reported from all the Great Lakes except Lake Erie. It is extirpated from much of its range, but remaining populations in Lake Superior appear to be stable. *Coregonus kiyi* does not enjoy specific legal protection from any jurisdiction in its range.

Le cisco kiyi, *Coregonus kiyi*, est une espèce indigène du bassin des Grands lacs, dont la présence a été signalée dans tous les Grands lacs sauf le lac Érié. Il est maintenant déraciné de la majeure partie de son aire de répartition mais demeure commun dans le lac Supérieur. On ne connaît pas sa biologie ni la situation de ses populations au Canada. Les juridictions qui couvrent son aire de répartition n'ont prévu aucune protection particulière pour *Coregonus kiyi* aux termes de la loi.

Key Words: Kiyi, *Coregonus kiyi*, ciscos, chubs, lake herring, coregonids, Great Lakes, Ontario.

The Kiyi, *Coregonus kiyi* (Koelz), is one of the smaller deepwater ciscos of the Great Lakes (Figure 1) and has an elongate, moderately compressed body with an average length of 25 cm and an average adult weight of about 0.2 kg, although some few individuals may have been longer and heavier. The head is long and narrow and the eyes large. This fish is rarely caught at depths shallower than 80 m and is known to inhabit waters at a depth of 180 m or more. The overall coloration is silvery with a pink or purple iridescence. The back is dark, the sides silvery, the ventral surface silvery white. Some individuals show light pigmentation on the fins and jaws.

Distribution

The Kiyi is indigenous to the Great Lakes basin (Figure 2) and formerly occurred in all the Great Lakes except Lake Erie (Koelz 1929). It is now considered extirpated in Lake Ontario and extremely rare or extirpated in lakes Huron and Michigan (McAllister et al. 1985; Todd 1980). It is still abundant in Lake Superior (W. McCallum, Ontario Ministry of Natural Resources (OMNR), Lake Superior Fisheries Assessment Unit, Thunder Bay, Ontario, personal communication).

The systematics of this species are unclear. Koelz (1929) described two subspecies: *Coregonus kiyi kiyi* in lakes Huron, Michigan, Superior, and *Coregonus kiyi orientalis* in Lake Ontario. However, Todd (1980) states that *Coregonus kiyi* is very similar to *Coregonus hoyi*, and has suggested that *C. kiyi* may be a deepwater variant of *Coregonus hoyi* (T. Todd, U.S. Fish and Wildlife Service, Ann Arbor, Michigan, personal communiation). Todd et al.(1981) state that *Coregonus hoyi* and *Coregonus kiyi* samples represented different genotypes adapted to different ecological conditions, but that the differences appear less than is generally accepted for the recognition of morphospecies. The American Fisheries Society (AFS 1980) does recognize *Coregonus kiyi* and *Coregonus hoyi* as distinct species.

Protection

No specific legal protection exists for this species in Canada or the United States.

Indirect protection of populations in United States waters of Lake Superior is provided through commercial catch quotas for deepwater ciscos as a group in Michigan waters (J. Peck, Michigan Department of Natural Resources, Marquette, Michigan, personal communication) and netting effort restrictions in Minnesota waters (J. Spurrier, Minnesota Department of Natural Resources, St. Paul, Minnesota, personal communication).

The deepwater cisco fishery in Michigan waters of Lake Huron has been closed since 1970 (A. Wright, Michigan Department of Natural Resources, Lansing, Michigan, personal communication), providing protection for possible remnant populations there. Recently instituted (1984) commercial harvest quotas for deepwater cisco also provide indirect protection for populations in Canadian waters of the Great Lakes (R. Payne, OMNR Lake Huron Fisheries Assessment Unit, Owen Sound, Ontario, personal communication).

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*Rare status assigned by COSEWIC — April 1988.

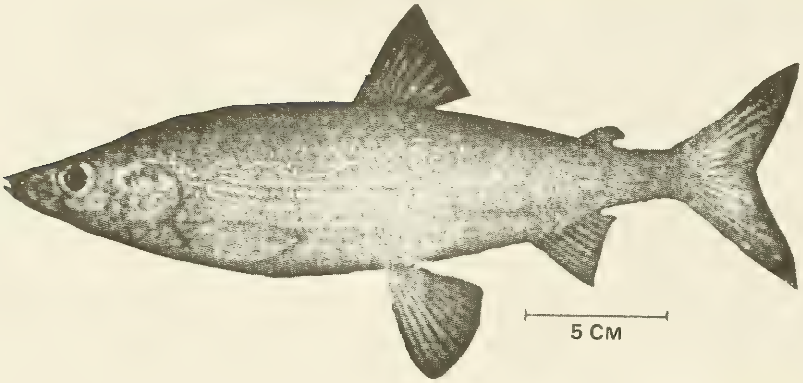

FIGURE 1. Kiyi, *Coregonus kiyi* (from Todd (1980) by permission).

Population Sizes and Trends

Coregonus kiyi was commercially important in Lake Ontario until the late 1930s (Koelz 1929; Pritchard 1931; Christie 1972). Populations declined in Lake Ontario in the 1940s (Stone 1944; Christie 1972), and the last known occurrence of the species was off Oswego, New York, in 1964 (Todd 1978). Recent surveys by the United States Fish and Wildlife Service and the New York Department of Environmental Conservation have not produced further specimens (T. Eckert, New York Department of Environmental Conservation, Albany, New York, personal communication). *Coregonus kiyi* is now considered extirpated in Lake Ontario (Todd 1980; W. Dentry, OMNR Lake Ontario Fisheries Assessment Unit, Picton, Ontario, personal communication).

Historical information regarding trends in Kiyi populations in Lake Superior is very limited, but W. McCallum (personal communication) considers the species common in Canadian waters. Capture data indicate that this species has remained relatively common in U.S. waters from 1958 to the present (Dryer 1966; Peck 1977; Pratt 1980). Wisconsin considers *Coregonus kiyi* populations in its jurisdiction to be stable (B. Swanson, Wisconsin Department of Natural Resources, Bayfield, Wisconsin, personal communication).

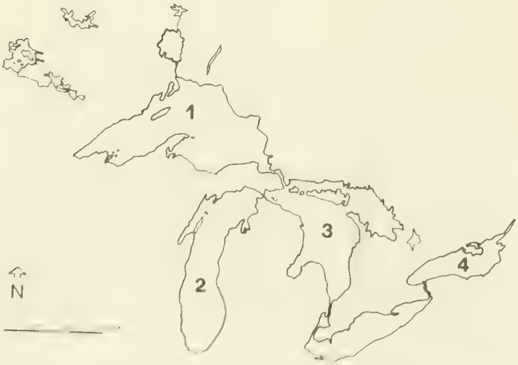

FIGURE 2. Distribution of the Kiyi, *Coregonus kiyi*: (1) Extant (Todd 1980); (2) Extremely rare, last specimen 1974 (Todd 1978, 1980); (3) Extremely rare, last specimen 1973 (Todd 1978, 1980); (4) Extirpated (Todd 1980).

Information regarding populations in Lake Huron is scarce. Koelz (1929) reported the species as widespread at deeper depths in Georgian Bay and the central basin of the main lake. The last known occurrence was at Griffith Island, Georgian Bay, Ontario, in 1973 (Todd 1978). A specimen tentatively identified as *Coregonus kiyi*, but unconfirmed by the Royal Ontario Museum (ROM), was captured in 1979 (R. Payne, personal communication). Subsequent surveys in Michigan waters of the lake have not produced further specimens (A. Wright, personal communication). Todd (1980) considers the species now extremely rare in Lake Huron.

Coregonus kiyi abundance in Lake Michigan declined steadily from the early 1930s to the early 1960s due to commercial overexploitation (Moffet 1957; Smith 1964). Todd (1978) reports that the last known occurrence was at Milwaukee, Wisconsin, in 1974. Subsequent collection attempts in Lake Michigan waters of Wisconsin (L. Kernan, Wisconsin Department of Natural Resources, Madison, Wisconsin, personal communication) and Michigan (A. Wright, personal communication, 1984) have not produced further authenticated specimens. Todd (1980) considers *Coregonus kiyi* as now extremely rare in Lake Michigan.

Habitat

Coregonus kiyi inhabits the deeper waters of the Great Lakes, occurring in greatest numbers at depths greater than 108 m, with the limits of distribution reported as 35 to 200 m (Koelz 1929; Pritchard 1931; Hile and Deason 1944; Dryer 1966; Anderson and Smith 1971; Peck 1977). Distribution is suggested as having been widespread at preferred depths (Koelz 1929; Pritchard 1931). Bottom type at capture locations is reported as clay and mud (Koelz 1929). Trends in habitat quality and rate of habitat change are both unknown. Insufficient information prevents an assessment of the degree of habitat specialization of this species, other than the depth preference noted above.

General Biology

Reproductive Capability: Hile and Deason (1944) reported that the spawning period in Lake Michigan was from September to November, and fish matured at age 2+ to 3+. Spawning in Lake Ontario was somewhat later, ranging from October to January (Pritchard 1931). Breeding frequency and fecundity information have not been reported for this species. In lakes Michigan and Ontario, females outlived males, attaining a maximum age of 10+ compared to 7+ for males. Females dominated both summer and spawing-run collections in Lake Michigan. Growth is slow, age-length relationships have been reported for Lake Ontario (Pritchard 1931) and Lake Michigan populations (Deason and Hile 1944).

Life history information for *Coregonus kiyi* populations in lakes Superior and Huron is limited. Spawning is reported to occur from November to December in Lake Superior and from October to November in Lake Huron (Koelz 1929). Koelz (1929) reported that *Coregonus kiyi* in Lake Superior mature at lengths as small as 132 mm standard length (SL). Todd (1980) reports adult size as 140 to 250 mm SL.

Species Movement: No information is available.

Behaviour/Adaptability: The degree of tolerance this species exhibits to human disturbance is not known. Intense commercial exploitation is believed to have caused the collapse of Lake Michigan and Lake Ontario populations (Moffet 1957; Smith 1964; Christie 1972). Populations in Lake Superior appear to be stable under present levels of exploitation (A. Wright; B. Swanson, personal communications). Information on the diet of this species is meagre. Food items in lakes Ontario and Huron consisted largely of the crustacean *Mysis relicta* and the amphipod *Pontoporeia hoyi* (Koelz 1929; Pritchard 1931).

Spawning sites are not well known. In Lake Michigan, Hile and Deason (1944) reported spawning was widespread at depths of 106 to 165 m, while in Lake Superior, a single report suggests spawning occurred at 128 m.

Limiting Factors

Overexploitation by the commercial fisheries is believed to have caused the decline of Lake Michigan and Lake Ontario populations (Moffet 1957; Smith 1964; Christie 1972) and possibly also those in Lake Huron (Berst and Spangler 1972).

Rainbow Smelt (*Osmerus mordax*) and Alewife (*Alosa pseudoharengus*) are food competitors with remnant cisco populations in lakes Huron and Ontario (Berst and Spangler 1972; Christie 1972) and may be suppressing a re-establishment of cisco populations. Colby et al. (1972) suggest that eutrophication may be a factor limiting the re-establishment of deepwater ciscos in Lake Ontario, possibly by interfering with reproduction. Recent studies indicate that although Lake Whitefish (*Coregonus clupeaformis*) and Lake Herring (*Coregonus artedii*) populations have improved in Lake Ontario, no deepwater ciscos have been reported (W. Dentry, personal communication).

Special Significance

This species was once commercially important in the lower Great lakes and is still harvested in Lake Superior. As part of the deepwater cisco community, it would have formed part of the traditional forage base for Lake Trout (*Salvelinus namaycush*) and Burbot (*Lota lota*).

Coregonus kiyi is endemic to North America and restricted to the Great Lakes basin. Other related cisco species, also endemic to the Great Lakes, have become extirpated or rare.

Evaluation

The following factors were used in the evaluation of the status of the Kiyi in Canada: (1) the species is endemic to the Great Lakes; (2) it is extirpated or extremely rare in much of its former range, but common to Lake Superior; (3) this species is afforded some protection in U.S. and Canadian waters by commercial catch quotas, netting effort restrictions and catch closure.

Based on the information evaluated, it is recommended that the Kiyi be considered vulnerable in Canada. Adequate management of this species in Lake Superior could allow for the viable continuance of this species. Long-term monitoring of the population status of this species should be considered.

Acknowledgments

This study has been funded by the Department of Fisheries and Oceans, Ottawa, and the Department of Supply and Services, Ottawa, under Contract No. OSZ83-00098.

I thank the staff of the Ontario Ministry of Natural Resources and members of various state agencies for supplying personal input and data summaries. I also greatly appreciate the assistance of D. E. McAllister, National Museum of Natural Sciences, and E. J. Crossman, Royal Ontario Museum, in providing access to museum records. Special thanks to T. Todd of the U.S. Fish and Wildlife Service for review of the manuscript.

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Status of the Black Redhorse, *Moxostoma duquesnei*, in Canada*

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Parker, B. J. 1989. Status of the Black Redhorse, *Moxostoma duquesnei*, in Canada. Canadian Field-Naturalist 103(2): 175–179.

The Black Redhorse (*Moxostoma duquesnei*) is threatened in Canada: reproducing populations are known only from the Thames and Grand river watersheds in southwestern Ontario. This species reaches its northeastern range limit in Canada and Canadian populations are geographically disjunct from those in the USA. Populations may be declining, possibly because of removal of adults and habitat alteration. The Black Redhorse is not specifically protected in Canada, although general protection is afforded by the habitat sections of the Canada Fisheries Act.

Le suceur noir (*Moxostoma duquesnei*) est une espèce menacée au Canada. Les populations qui se reproduisent ne se rencontrent que dans les bassins versants des rivières Thames et Grand, dans le sud–ouest de l'Ontario. La limite nord–est de l'aire de répartition de cette espèce se trouve au Canada, et les populations canadiennes sont séparées géographiquement de celles des États-Unis. Il se peut que les populations soient en baisse à cause de la disparition des adultes et de la transformation de l'habitat. Le suceur noir n'est pas protégé de façon particulière au Canada, bien que les articles de la Loi sur les pêcheries du Canada concernant l'habitat lui accordent une protection générale.

Key Words: Black Redhorse, le suceur noir, *Moxostoma duquesnei*, suckers, redhorse, Catostomidae, rare and endangered fishes, Ontario.

Although generally known as redhorses, members of the genus *Moxostoma* are part of the Catostomidae or sucker family. All members of the group including the Black Redhorse are superficially similar to other suckers of the genus *Catostomus*, but are usually larger and have a three-chambered swim (gas) bladder rather than two.

The Black Redhorse (*Moxostoma duquesnei* Lesueur) closely resembles the Golden Redhorse (*Moxostoma erythrurum*) but is usually smaller (less than 45 cm in length) and has more scales along the lateral line (Figure 1). The slate-coloured tail distinguishes it from the other redhorses, which have red tails. The overall colouration is gray to brown; the sides are usually lighter and silvery. The ventral surface is usually milk white and the fins slate gray.

Distribution

The Black Redhorse is found through much of the Mississippi River system, its range extending north into Canada in the Great Lakes basin (Figure 2). Jenkins (1980) summarized the current knowledge of the species' distribution. In Canada, the Black Redhorse has been reported only from Catfish Creek and the Grand, Thames and Maitland river watersheds (Figure 3)[1]. The closest extant populations to those in Canada are in Michigan.

Protection

International: The species has been listed as threatened in West Virginia (Miller 1972) and rare in Iowa, Wisconsin and Minnesota (Harlon and Speaker 1969; Jenkins 1970); however, the level of protection afforded by these designations is unknown.

National: The species is not specifically protected in Canada, although fish habitat sections of the Fisheries Act of Canada do provide general protection. Locally, sections of the Nith River have been designated as environmentally sensitive (G.M. Tupling, Ontario Ministry of Natural Resources, Cambridge, Ontario, personal communication). It is tentatively identified as a "peripheral species" by the Ontario Ministry of Natural Resources (D.R. Johnston, Ontario Ministry of Natural Resources, Toronto, Ontario, personal communication).

Population Size and Trends

Hubbs and Brown (1929) first reported the Black Redhorse in Canada from tributary streams

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*Threatened status assigned by COSEWIC April 1988.

[1] Three Royal Ontario Museum collections of juveniles collected in the Maitland and Bayfield river watersheds and tentatively identified as *Moxostoma duquesnei* were not included. Identification of juvenile suckers requires further review.

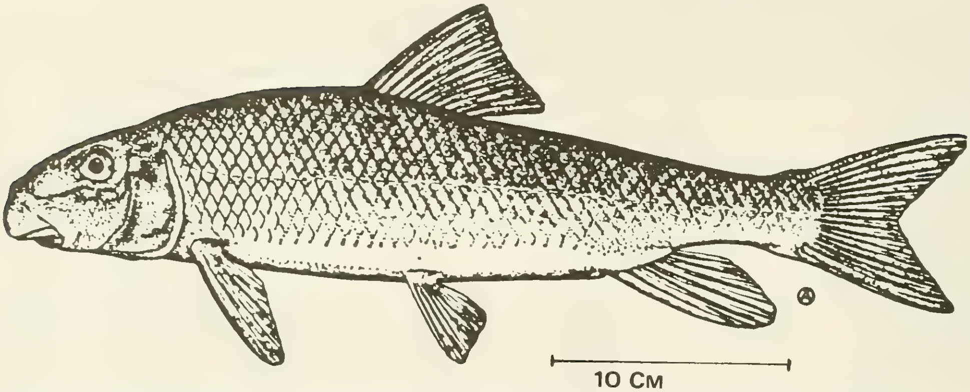

FIGURE 1. Black Redhorse, *Moxostoma duquesnei* [from Scott and Crossman (1973) by permission].

flowing into Lake Erie. Several collections were made up to 1939, but repeated attempts to collect this species in subsequent years failed to confirm its continued existence in Canada. A span of 35 years passed before the Black Redhorse was again collected in Canada, first from the Maitland River,

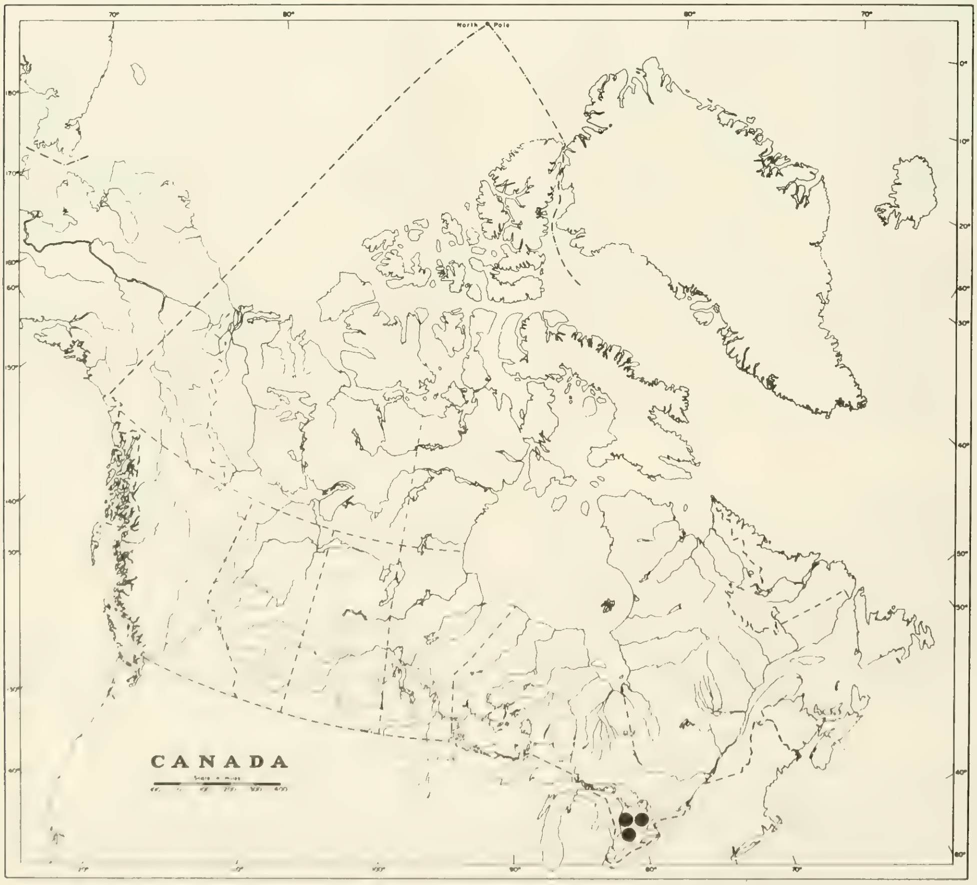

FIGURE 2. Canadian distibution of the Black Redhorse, *Moxostoma duquesnei*.

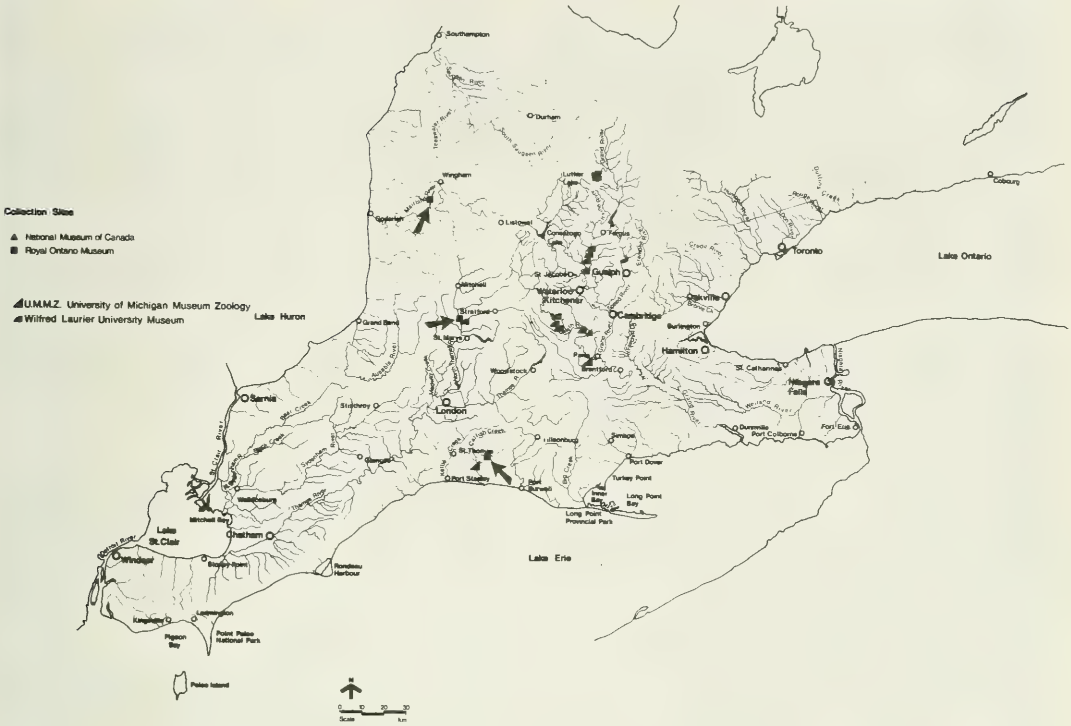

FIGURE 3. Collection records of *Moxostoma duquesnei* in Ontario.

a tributary to Lake Huron, and then from the Grand River system (Kott et al. 1979) and the Thames River watershed (Gartner Lee Associated 1981). Self-sustaining populations are known only from the Thames and Grand river systems.

The Grand River population has been most studied. Adults and juveniles have been reported at several sites on the upper Grand River near Elmira and in the Nith River southwest of the city of Cambridge. These two population sub-units are small and are limited to specific river sections having suitable habitat. This species is rare even at population centrums; approximately 1 in 10 redhorse suckers collected are Black Redhorse. Although a finite population estimate has not been formulated, observations from this population between 1977 and 1982 suggest a downward trend in population size. As a result, the collection of specimens for scientific study was curtailed in 1982 in an effort to avoid possible impact on the population.

The Thames River Black Redhorse population is little known. Gartner Lee Associated (1981) first reported this species in the Thames River on the basis of several juvenile specimens. A small collection of breeding adults was made near the original capture site in 1982. No other specimens have been reported. This population is believed even smaller than the Grand River population.

Attempts to confirm the continued presence of this species in the Maitland River have proven unsuccessful. Surveys in 1980, 1981 and 1982 for the express purpose of collecting Black Redhorse in this watershed failed.

The origins of the Black Redhorse populations are unknown; however, a review of collection and population data suggests that the Grand River population may have served as the source for the populations in Ontario. Headwater areas of the Grand, Thames and Maitland rivers are in very close proximity and may have been connected in recent times. This theory would suggest that natural revitalization of Canadian populations from populations in the United States is unlikely and that the Canadian population is distinct and unique from other Black Redhorse populations.

Habitat

The Black Redhorse has been reported in Canada from moderately sized rivers with sand, gravel and bedrock substrates where siltation is minimal. The water quality at capture sites in southern Ontario may be characterized as well oxygenated and relatively fertile; July water temperatures average 20°C. This species is found in the Grand River system where the gradient ranges from 1.2 to 1.5 m/km. It is captured infrequently in sluggish environments, which have an abundant growth of macrophytes or soft substrates.

Impoundments and slow moving rivers where the substrates are silted furnish relatively little suitable habitat. Various surveys in the United States have shown that Black Redhorse populations decline following impoundment of their habitat (Bowman 1959).

The Black Redhorse spawns over gravel and stone substrates in fast flowing shallow waters, usually less than 0.5 m deep. Nursery areas in the Nith and Thames rivers normally incorporate shallow pools and areas of slackened currents.

General Biology

No comprehensive studies of the life history of this species in Canada exist. However, much of the available information has been presented by McAllister et al. (1985).

Reproductive Capability: In Canada, the Black Redhorse spawns in late May or early June. Adults have been observed on the spawning grounds as early as 15 May at water temperatures of 9°C. Spawning activity intensifies as the water temperature approaches 15°C and lasts seven to eight days. These data are supported by Bowman (1959), who also noted that spawning takes place in a temperature range of 13 to 22°C.

Spawning activities have been observed in the Grand River population and were similar to that described by Bowman (1970). Fertilized eggs are deposited in the gravel of the spawning shoal. Kott and Rathmann (1985) provided estimates of fecundity for Black Redhorse in the Grand River, which ranged from 4126 to 11551 eggs per female. Eggs are non-adhesive and range from 2.6 to 2.9 mm in diameter at spawning. The egg incubation period is unknown. Larval development has not been described for Ontario populations but is not expected to differ from that reported by Bowman (1959).

Sexual maturity is at about age 4 for both sexes. Once mature, males and females are believed to spawn every year. The oldest specimen collected in Canada was aged at 8 years; the maximum age for the species is reported at 10 years (Bowman 1959). The Black Redhorse is smaller than some species of redhorse suckers and may only reach a length of 400–450 mm and a weight of 1250 g. A length–weight relationship has not been developed for Canadian populations; however, age–length data for several specimens from the Grand River were reported by Parker and Kott (1980).

Food habits are unknown in Canada, all adult specimens taken during the spawning period had empty foreguts. Bowman (1959) reports that juveniles feed on plankton, progressing to soft-bodied invertebrates with increasing size to adulthood. Susceptibility to sport fishing is unknown.

Species Movement: The Black Redhorse inhabits very localized sections of the Grand and Thames rivers. Spawning migrations have been reported in more southerly populations (Bowman 1959) but not in Canada. Spawning migrations in Canada may, however, be blocked by existing physical barriers and sections of unsuitable habitat. During the summer, adults may be found feeding at the base of riffles, but as fall approaches a gradual return to the deeper runs in the river occurs for the over-wintering period.

Limiting Factors

The Black Redhorse is restricted in Ontario to low-silt areas of moderate-to-high-gradient streams. In the Grand and Thames rivers, several dams have reduced the amount of suitable habitat available. Reservoir development on these watersheds would destroy Black Redhorse spawning and nursery habitats.

Few field biologists are able to identify the Black Redhorse. In all but a very few instances, all redhorse suckers are lumped together as one taxon for reporting purposes. Our ability to manage the Black Redhorse populations in Canada is thus reduced.

Special Significance

The Black Redhorse has no commercial importance in Canada. Populations in Canada are at the northern extremity of their range and are non-contiguous with more southerly populations. The significance of this species in Canada is similar to that of others disjunct from their continuous population and therefore isolated and extremely sensitive to environmental change.

Evaluation

The Black Redhorse has a restricted distribution in Canada; breeding populations are known from only two river systems. In both of these watersheds, this species is confined to relatively small areas that have specific habitat qualities. These habitats may be destroyed if the hydraulic integrity of the river sections is altered from present conditions. At present, two localities where the Black Redhorse were collected have been selected as potential dam sites, although neither are slated for immediate construction. If these construction projects proceed, the Black Redhorse could be eradicated at the sites.

Acknowledgments

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No. FP802-4-2183 and is an update of Parker and Kott (1980). I wish to thank R. R. Campbell, Fisheries and Oceans, and D. E. McAllister, National Museum of Natural Sciences, for their support and advice during the preparation of this report. Thanks also to P. McKee, Beak Consultants, for supplying the base map for Figure 3.

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Status of the Hornyhead Chub, *Nocomis biguttatus*, in Canada*

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Dalton, K. W. 1989. Status of the Hornyhead Chub, *Nocomis biguttatus*, in Canada. Canadian Field Naturalist 103(2): 180–185.

The Hornyhead Chub (*Nocomis biguttatus*) has a limited distribution in Canada, although range extensions and reductions appear to have occurred within the past 60 years. Siltation and turbidity seem to be major limiting factors for this minnow. The species may be of some importance in the maintenance of forage minnow stocks. No specific protection exists but the species is given general protection through the fish habitat sections of the Fisheries Act.

Au Canada, le tête à taches rouges (*Nocomis biguttatus*) a une répartition restreinte quoique l'aire de répartition ait subi d'importantes variations au cours des 60 dernières années. L'envasement et la turbidité semblent être les principaux facteurs limitatifs de l'espèce qui peut jouer un certain rôle dans le cycle vital de ménés proies. Le tête à taches rouges ne fait pas l'objet d'une protection particulière sauf d'une protection générale en vertu des articles sur la protection de l'habitat du poisson de la Loi sur les pêcheries.

Key Words: Hornyhead Chub, *Nocomis biguttatus*, cyprinids, freshwater fishes, Ontario.

Hornyhead Chub, *Nocomis biguttatus* (Kirtland 1841), are small, elongate cyprinids averaging about 89 mm in length in Canada, although much larger specimens have been reported from some American waters, some even as long as 250 mm in total length (Lachner 1952; Scott and Crossman 1973). The maximum size recorded in Ontario is a male 161 mm total length taken from the Bayfield River (Scott and Crossman 1973). These minnows (Figure 1) have wide heads with bluntly triangular snouts and moderately large, nearly terminal mouths. A small terminal barbel is located in the angle of the upper and lower jaw. The single opaque dorsal fin is above the pelvic fins, at about the mid-length of the body. The large cycloid scales are outlined by melanophores situated along the scale margins (Scott and Crossman 1973).

Juveniles and non-breeding adults are generally olive-brown on the back and have silver sides which blend with creamy white undersides (Scott and Crossman 1973). Changes in morphology and colour occur in male Hornyhead Chub during the breeding season; this characteristic can be used to distinguish the fish from closely related species such as the River Chub, *Nocomis micropogon*, (Lachner 1952; Lachner and Jenkins 1967; Ferguson et al. 1981).

Many well developed tubercles grow on the head of breeding males and small tubercles freckle the outer margins of the pectoral fin anterior rays (Lachner 1952). The lateral stripe, which is otherwise faded and obscure on mature males, becomes intensely black during the breeding season (Lachner 1952). Other colour features of breeding males include a light red spot behind the eye and orange dorsal and anal fins (Lachner 1952; Scott and Crossman 1973).

Changes in the colour patterns of female Hornyhead Chub also occur in the breeding season. Noticeable alterations occur in the fins; the medial fins become orange and the paired fins develop light yellow-orange colours. Other body parts also demonstrate change in coloration (*see* Lachner 1952).

Distribution

The Hornyhead Chub has a moderately wide distribution in North America. In the United States the range (Figure 2) extends from New York and Ohio west to the Red River drainage of Minnesota and the Dakotas (Lachner and Jenkins 1971; Scott and Crossman 1973; Jenkins and Lachner 1980). The range extends south to the Ozarks in Georgia and Alabama and a disjunct population exists in Colorado and Wyoming (Scott and Crossman 1973; Jenkins and Lachner 1980).

In Canada the species is found in the Great Lakes basin (Figure 3), in tributaries of lakes Ontario, Erie, St. Clair and eastern Lake Huron (Scott and Crossman 1973). *Nocomis biguttatus* has also been collected from lakes in the Algoma district, in the northwestern Lake Huron drainage. Scott and Crossman (1973) and K. W. Stewart (University of Manitoba, Winnipeg, Manitoba, personal communication) have reported Horny-

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*Not in jeopardy in Canada: NIAC (Not in Any COSEWIC Category) April 1988.

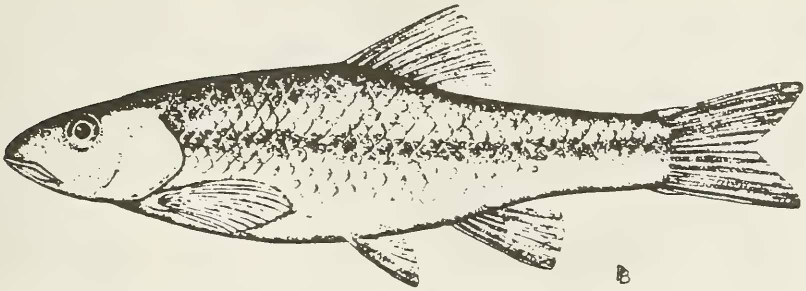

FIGURE 1. Hornyhead Chub, *Nocomis biguttatus* (from Scott and Crossman (1973) by permission).

head Chub in Manitoba, from tributaries of the Winnipeg River, the Brokenhead and Whitemouth rivers and Hazel Creek (Figure 3).

The building of the Trent-Severn Waterway from Georgian Bay (Lake Huron) to eastern Lake Ontario between 1833 and 1920 (Department of Fisheries and Oceans 1984) provided over 300 km of navigable inland waters for human commercial and recreational uses, and a possible route of colonization for the Hornyhead Chub. The species was not present in eastern Lake Ontario tributaries before this artificial connection was built (M. Rouse, Royal Ontario Museum, Toronto, Ontario, personal communication). Tributaries of the Trent River, Rice Lake, and Lake Ontario also now contain *Nocomis biguttatus* communities.

Protection

Nocomis biguttatus has no specific protection in Canada, but does receive incidental protection through the fish habitat sections of the Fisheries Act.

The species is classified as rare in Nebraska and South Dakota, as well as rare and endangered in Wyoming (Miller 1972). Johnson (1987) reports this species as of special concern in Kansas, Kentucky, North and South Dakota, Wyoming and Manitoba, and as not protected by any state or province of the United States or Canada.

Population Size and Trends

Collection records maintained by the Ontario Ministry of Natural Resources; the National Museum of Natural Science, Ottawa; and the Royal Ontario Museum, Toronto; from the early to mid-1970s show widespread distribution of *Nocomis biguttatus* across southern Ontario (Figure 4) as well as the species' presence in scattered pockets elsewhere in the province. The fish is widespread in some watersheds, but usually numbers less than half a dozen in a seine haul, although occasionally 30 or 40 may be taken (D. E. McAllister, National Museum of Natural Sciences, Ottawa, Ontario, personal communication). Natural factors, such as low-lying geography resulting in slow, turbid streams, may account for this distribution in some parts of southern Ontario.

Ontario Ministry of Natural Resources (OMNR) records indicate that some reductions of range and numbers of the species may have occurred in urban areas and areas of intense cultivation, probably due to increased pollution

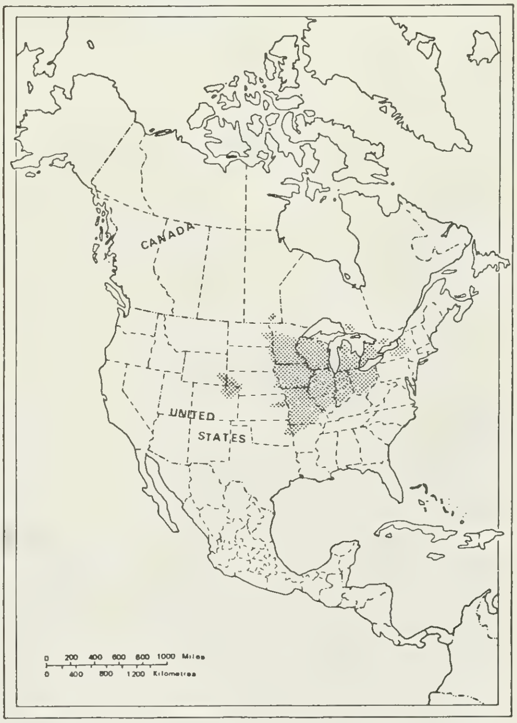

FIGURE 2. North American distribution of Hornyhead Chub (*Nocomis biguttatus*).

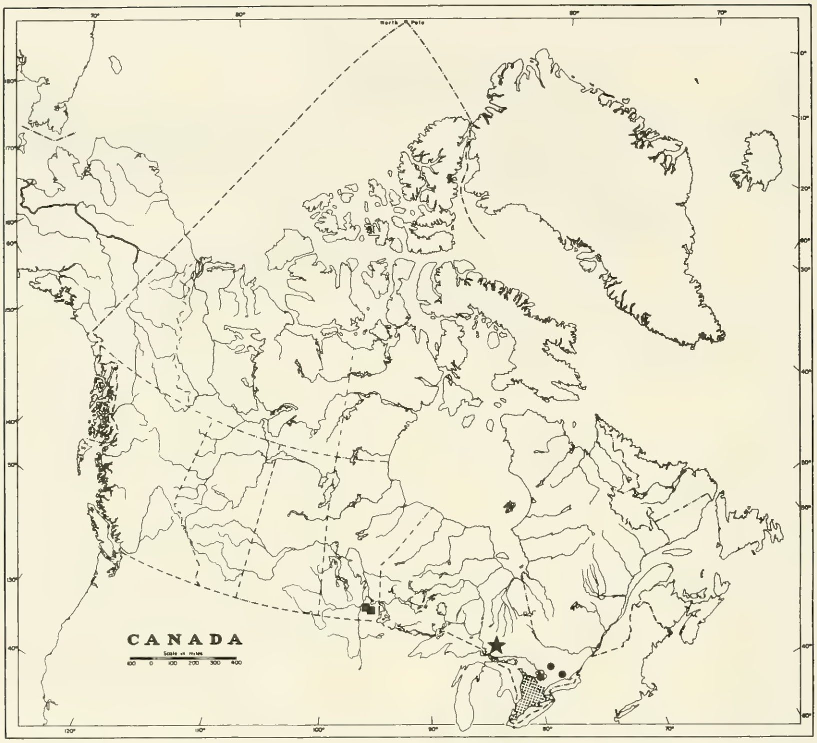

FIGURE 3. Distribution of Hornyhead Chub in Canada: Manitoba distribution ■; Traditional range ⁙ ; Algoma district of northern Ontario ★; Disjunct southern Ontario collections ●.

and siltation. Some tributaries of Lake Erie and Lake Ontario no longer appear to support many, if any, Hornyhead Chub.

Collections from the Detroit River in 1986 and 1984 collections from Sixteen Mile Creek, a northwest Lake Ontario tributary, indicate the continuing presence of the species in these areas. Specimens from Sixteen Mile Creek ranged from 23 to 42 mm in length (G. Gale, OMNR, Toronto, personal communication). These specimens were juvenile (*see* Biology), indicating the presence of a breeding population in the creek.

Recent collection information is scarce, there has been a general lack of effort in stream collecting since the 1970s in favour of lake sampling. Collecting from creeks and rivers should resume within a few years (G. Gale, personal communication). The available information indicates stable populations in the watersheds that have been sampled within the last five years throughout most of the Hornyhead Chub's range in southern Ontario.

Since the opening of the Trent-Severn Waterway from Georgian Bay to Lake Ontario, the species has apparently made a series of successful colonizations, possibly via the waterway. Specimens have been collected along the waterway, although very infrequently, and are not indicative of large populations.

Hornyhead Chub seem to have made other range extensions into three lakes in the Algoma district of northern Ontario (Figure 4). These lakes are several hundred kilometers from the nearest point of the traditional *Nocomis biguttatus* range. How the species made this colonization is unknown, but an accidental release of bait fish is possible. Another explanation is that Hornyhead Chub are natural residents of the area but were undiscovered until collected by OMNR personnel in 1974. The former is the more likely (G. Goodchild, OMNR, Toronto, personal communication), especially since it is lakes rather than streams which are being colonized. Increased abundance of forage fish could have repercussions further along the food chain. Information from future surveys and observations of spawning behaviour of minnows in the district are required to determine and assess such effects.

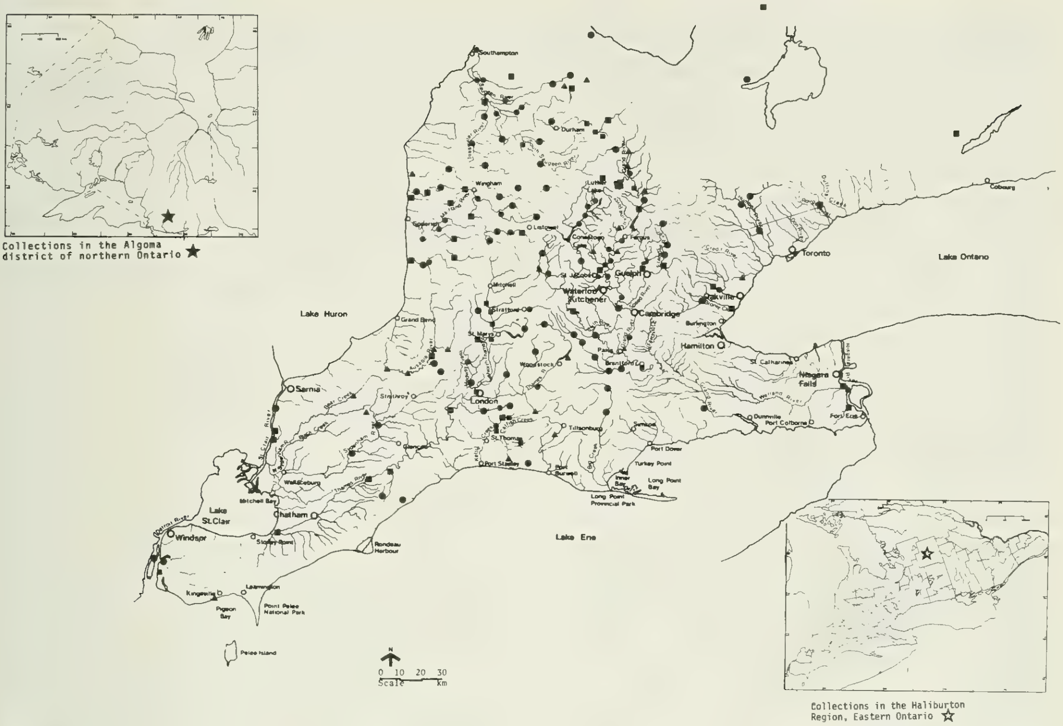

FIGURE 4. Collection records of *Nocomis biguttatus* in Ontario: ▲ National Museum of Natural Sciences; ■ Royal Ontario Museum; ● Ontario Ministry of Natural Resources.

In Manitoba, the species is common to abundant in the Whitemouth River and common in the Brokenhead River (K. W. Stewart, personal communication).

Habitat

Hornyhead Chub are usually found in slow moving, small to medium-sized streams, most often tributary to large rivers (Lachner 1952; Scott and Crossman 1973; Jenkins and Lachner 1980). Ample current to keep the bottom clear of mud, silt and sand is probably required (Lachner and Jenkins 1967). Streams with shifting sand and silt are not favoured by Hornyhead Chub (Greene 1935: 75 *in* Lachner 1952). Water temperatures vary from cool to warm, and water clarity is usually good (Jenkins and Lachner 1980; Scott and Crossman 1973).

Bottom substrates range from gravel to boulders. Larger chub are often found in pools and slower portions of creeks and rivers among large rocks and boulders, while the smaller, younger fish prefer beds of smaller stones and weedbeds of rooted aquatic plants (Lachner 1952; Scott and Crossman 1973; Jenkins and Lachner 1980).

Gravelly, rocky river bottoms provide much of the invertebrate fauna required by all members of the species for food. The gravel supplies materials required for nest construction by mature male chub (Lachner and Jenkins 1967).

General Biology

Although Hornyhead Chub are omnivores, different food types are favoured in different stages of their life. The diet of young fish consists mostly of plant material but diatoms, cladocerans and aquatic insect larvae are also eaten (Scott and Crossman 1973). Progressively larger foods are eaten and the importance of aquatic flora is reduced as the fish grow (Scott and Crossman 1973). Larger insect larvae, annelids, crayfish, fish, and especially snails become increasingly important (Scott and Crossman 1973). The barbels have few taste buds and Hornyhead Chub are predominantly sight-feeders (Carlander 1969).

Data given by Scott and Crossman (1973) indicate the size and range in size of the species at different ages. Males tend to grow faster and attain larger sizes than females (Lachner 1952). The largest specimen in the Royal Ontario Museum collection is a male, 161 mm in total length, taken from the Bayfield River of the Lake Huron drainage in Ontario (Scott and Crossman 1973). Hornyhead Chub generally reach sexual maturity at three years of age (86 to 100 mm standard length in Ontario (Scott and Crossman 1973)), but fast growing individuals of both sexes are mature when two years old (Lachner 1952).

Like other members of the genus *Nocomis*, males build large, dome-shaped nests of gravel and pebbles (Lachner 1952; Scott and Crossman 1973). A nesting site is selected, usually below a riffle, with a fine gravel or pebble bottom. The water must be deep enough to accommodate the completed nest, 50 to 150 mm high, plus ample headroom, 150 to 450 mm (Scott and Crossman 1973).

Each spawning act is performed over the nest in only a few seconds; the eggs fall between the stones of the nest and are immediately covered with more gravel by the male. Thus, the nest grows with each successive spawning act and the eggs are afforded some protection from predatory fish (Lachner 1953; Scott and Crossman 1973).

Females do not lay their entire egg complement at once; only the ripe eggs are deposited in each act. As many as 10 females are believed to spawn on a single nest (Carter 1940 *in* Scott and Crossman 1973).

The Common Shiner (*Notropis cornutus*) and Hornyhead Chub are often found in the same rivers and creeks (Lachner 1952) and there may be a commensal relationship between the two species (Hankinson 1932 *in* Lachner 1952).

Hornyhead Chub are very similar to River Chub (*Nocomis micropogon*), and identification of specimens from either group can be very difficult (Lachner 1952; Ferguson et al. 1981). Secondary sex characteristics on mature males, which are present only in breeding season, are the only external distinguishing features between the two species (Ferguson et al. 1981). Ferguson et al. (1981) have biochemically characterized both species, confirming the taxonomic distinction between them and indicating that they are sibling species. In spite of the fact that Hornyhead and River chub share many morphological and lifestyle similarities and often live in the same or adjacent waters, they do not seem to interbreed often (Ferguson et al. 1981). Further investigation of the mechanisms used by these fish for species recognition, reproductive isolation and ecological segregation would be a productive area of study (Ferguson et al. 1981).

Limiting Factors

Lakes and large rivers seldom harbour *Nocomis biguttatus* (Jenkins and Lachner 1980). The species habitat is largely limited to small gravelly streams and rivers, often tributary to large rivers (Scott and Crossman 1973). Mud and silt bottom substrates are not tolerated and turbidity is limiting to this sight feeding species (Lachner and Jenkins 1967, 1971; Scott and Crossman 1973).

Trautman (1957) lists several limiting factors resulting from agricultural practices. Resultant silt can cover course bottom substrates and cloud the water. Irrigation and land development reduce water flow and volume, sometimes resulting in intermittent streams (Lachner and Jenkins 1971). Increased competition from species better adapted to silty, turbid waters further aggravates the problems of Hornyhead Chub (Lachner and Jenkins 1971).

Special Significance of the Species

Other species of minnows have been observed using the nests of *Nocomis* species (Reighard 1940; Lachner 1952; Scott and Crossman 1973; and others). The many nest associates include shiners, dace, darters, and others (*see* Lachner (1952) for a more complete and specific list). The close proximity of nesting sites of different species can lead to accidental cross-fertilization, resulting in various hybrids (Lachner 1952). In rivers and streams where suitable nesting grounds are limited, nests of *Nocomis* species may have great ecological and economic significance (Lachner 1952). Provision of suitable spawning grounds may be important in sustaining forage minnow abundance (Lachner 1952).

Because of their large size and hardiness, Hornyhead Chub were a favorite bait fish in the northern United States (Scott and Crossman 1973). The species was widely used for food and bait in Ohio until its range and population declined to scattered relicts by 1950 (Trautman 1957). The restricted range of the chub in Canada limits their importance as bait fish in Canadian waters (Scott and Crossman 1973). It is not likely that bait dealers and anglers distinguish Hornyhead Chub from the more common Creek Chub, *Semotilus atromaculatus*, (Scott and Crossman 1973).

Evaluation

Hornyhead Chub are widely distributed across southern Ontario and the populations of the major drainage systems appear to be stable. Although some populations in southwestern Ontario may have been affected by habitat deterioration, populations appear to be stable and range extensions have recently occurred along the Trent-Severn Waterway and in the Algoma district. Population sizes and trends are unknown in these regions. Further surveying of creeks, rivers and lakes in these areas is required for a proper evaluation of the species' local status and ecological effects. Even though the species is not widespread in Manitoba, it appears to be common where found. Based on the information available, the Hornyhead Chub does not seem to be in jeopardy in Canada at this time.

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Status of the River Chub, *Nocomis micropogon*, in Canada*

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Dalton, K. W. 1989. Status of the River Chub, *Nocomis micropogon*, in Canada. Canadian Field-Naturalist 103(2): 186–192.

The River Chub, *Nocomis micropogon*, is a North American cyprinid found in medium-sized streams and rivers of the Great Lakes and Mississippi basins. In Canada, its distribution is restricted to southern Ontario where it occurs in tributaries to lakes Ontario, Erie and Huron. Data are inconclusive but indicative of there being large isolated populations, as well as diminished populations closer to centres of human activity. A recent range extension of River Chub into Eastern Ontario seems to be a successful colonization in a new watershed. This may have interesting ecological implications involving the overall forage minnow populations of waters where the River Chub is present. The overall range and abundance of the species in Canada does not appear to be declining.

Le méné bâton, *Nocomis micropogon*, est un cyprinidé nord-américain que l'on trouve dans les rivières et les cours d'eau de taille moyenne des bassins des Grands Lacs et du Mississippi. Au Canada, son aire de répartition est limitée au sud de l'Ontario; on ne le rencontre en effet que dans certains tributaires des lacs Ontario, Érié et Huron. Nos données sont incomplètes mais révèlent qu'il existe d'importantes populations isolées et que les populations vivant à proximité des centres urbains ont diminué. L'extension récente de l'aire de répartition du méné bâton vers l'est de l'Ontario pourrait signifier que l'espèce a réussi à s'introduire avec succès dans un nouveau réseau hydrographique. Ceci pourrait avoir d'intéressantes répercussions écologiques sur les populations de cyprins utilisés comme poisson fourrage qui vivent dans des eaux où le méné bâton est présent. L'aire de répartition et l'abondance de l'espèce au Canada ne semblent pas diminuer.

Key Words: River Chub, *Nocomis micropogon*, cyprinids, minnows, southwestern Ontario.

The River Chub, *Nocomis micropogon*, is a stout, elongate minnow averaging about 102 mm in length (Figure 1). It has a wide head which ends in a long, bluntly rounded snout with a large, nearly terminal mouth.

The origin of the single opaque dorsal fin is above the origin of the pelvic fin; the pectoral fins are rounded and well developed. Large cycloid scales cover the body and are outlined by melanophores (Scott and Crossman 1973).

In juvenile River Chub and non-breeding adults, the back is olive-brown and the sides are silvery, blending into a creamy-white underside. A dark lateral band, most prominent in young chub, extends from the snout, through the eyes and along the lateral line on each side (Scott and Crossman 1973). The lateral band fades away as the fish grow older, becoming faint or diffuse black (Lachner 1952).

Both sexes of adult River Chub undergo changes during the breeding season. Adult males grow tubercles on the dorsal anterior parts of the head and on the anterior edges of the pectoral fins. The tubercles on the head are well developed, much more so than the tubercles on the pectoral fins (Reighard 1943; Lachner 1952; Lachner and Jenkins 1967; Scott and Crossman 1973). Tubercles are lost by abrasion during spawning or nest-guarding (Lachner 1952). On older males especially, the integument bearing the head tubercles swells into a large hump (Reighard 1943; Lachner 1952; Scott and Crossman 1973). Breeding males also develop brilliant colours and their undersides become reddish (Lachner 1952). The dorsal and caudal fins are yellowish though the rays have black pigment along their length, and red tips (Lachner 1952). The anal fin and the paired fins are olive-yellow with whitish ray tips (Lachner 1952).

Ripe females are not as distinctly coloured as the males. The anal fin and the paired fins are pale yellow and the undersides have a light gray tone. Tubercles are not developed on female chub and are present only as white spots in the integument (Lachner 1952).

Distribution

The species is a North American cyprinid distributed through the Great Lakes basin, from Lake Champlain west as far as Michigan and Indiana, and on the Atlantic slope as far south as northern Alabama and Georgia (Figure 2). In Canada, the fish is found in creeks and rivers throughout most of southern Ontario, from

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*Not in jeopardy in Canada (therefore not in any COSEWIC category) April 1988.

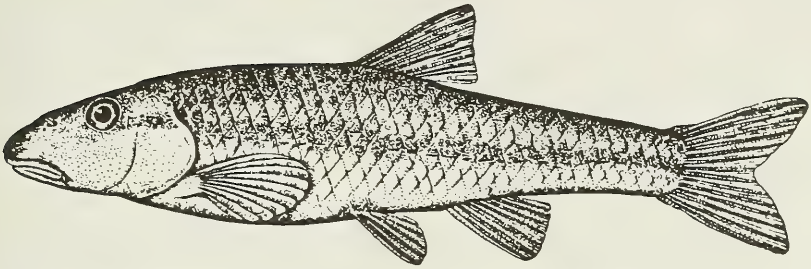

FIGURE 1. River Chub, *Nocomis micropogon*, (from Scott and Crossman 1973, by permission).

Georgian Bay south to Lake Erie and the northwestern tributaries of Lake Ontario (Figures 3, 4) (Scott and Crossman 1973; Jenkins and Lachner 1980).

The Royal Ontario Museum (ROM), the National Museum of Natural Sciences (NMNS) and the Ontario Ministry of Natural Resources (OMNR) records do not show any collections from the Windsor Peninsula of Southwestern Ontario (Figure 4). The geography of this region is low-lying and relatively flat and creeks and rivers therein are shallow, slow-moving and turbid. The species may be absent from this area due to lack of suitable habitat [R. Campbell, Department of Fisheries and Oceans (DFO), Ottawa; personal communication].

River Chub appear to have established a disjunct population in the Madawaska River, a tributary of the Ottawa River. Goodchild and Tilt (1976) suggest that the species may have been introduced to the Madawaska River by an accidental release of bait fishes.

A 1979 collection (ROM *40644*) from the Hollow River, near the Lake of Bays (Figure 3), was confirmed by the ROM laboratories (E. Holm, ROM, personal communication). The presence of the species here may be similar to the Madawaska River introduction. Collections were also reported from Lichen and Fleet lakes west of Lake Nipigon in 1954 and 1982 respectively. However, these are unconfirmed (E. Holm; B. Morton, OMNR, Toronto; personal communications).

Protection

In Canada, the River Chub is not specifically protected but does receive some incidental protection through the fish habitat sections of the Fisheries Act.

At present, the species is not of any concern, nor is it awarded any specific protection, in the United States. The closely related species, the Hornyhead Chub, *Nocomis biguttatus*, is listed as rare in Nebraska and South Dakota as well as rare and endangered in Wyoming (Miller 1972). McAllister et al. (1985) and Johnson (1987) did not list this species as one of special concern due to low numbers, limited distribution or as receiving any special protection in the United States or Canada.

Habitat

The River Chub inhabits swift currents and pools in medium sized streams and rivers of high to moderate gradients. Bottom substrates range from gravel to boulder. Warm, clean water is usually required (Scott and Crossman 1973; Jenkins and Lachner 1980). The species spawns at temperatures between 19° C and 28° C (Carlander 1969).

Waters with plant growth are usually avoided although Lachner (1952) reports that the species occurs abundantly in some streams of the Lake Ontario drainage in New York where algae and vascular plants flourish.

Population Size and Trends

Isolated populations of River Chub appear to be large while other communities closer to dense human populations do not seem to be doing as well.

Nocomis micropogon was thought to be scarce or absent from much of its former range in western Lake Ontario tributaries (Scott and Crossman 1973). However, collections undertaken by NMNS, OMNR and ROM in the early 1970s and in 1981 indicate the continued presence of River Chub in these watersheds, despite the proximity of urban, industrial and agricultural activities.

The numbers and sizes of specimens caught in the Madawaska River and its tributaries, indicate that a substantial breeding population is present in the Madawaska River watershed (Goodchild and Tilt 1976). This medium-sized river feeds into the Ottawa River, a large river draining portions of northern Ontario and western Quebec. The river is generally wide and of varied bottom substrate and inclinations. It could become an avenue of

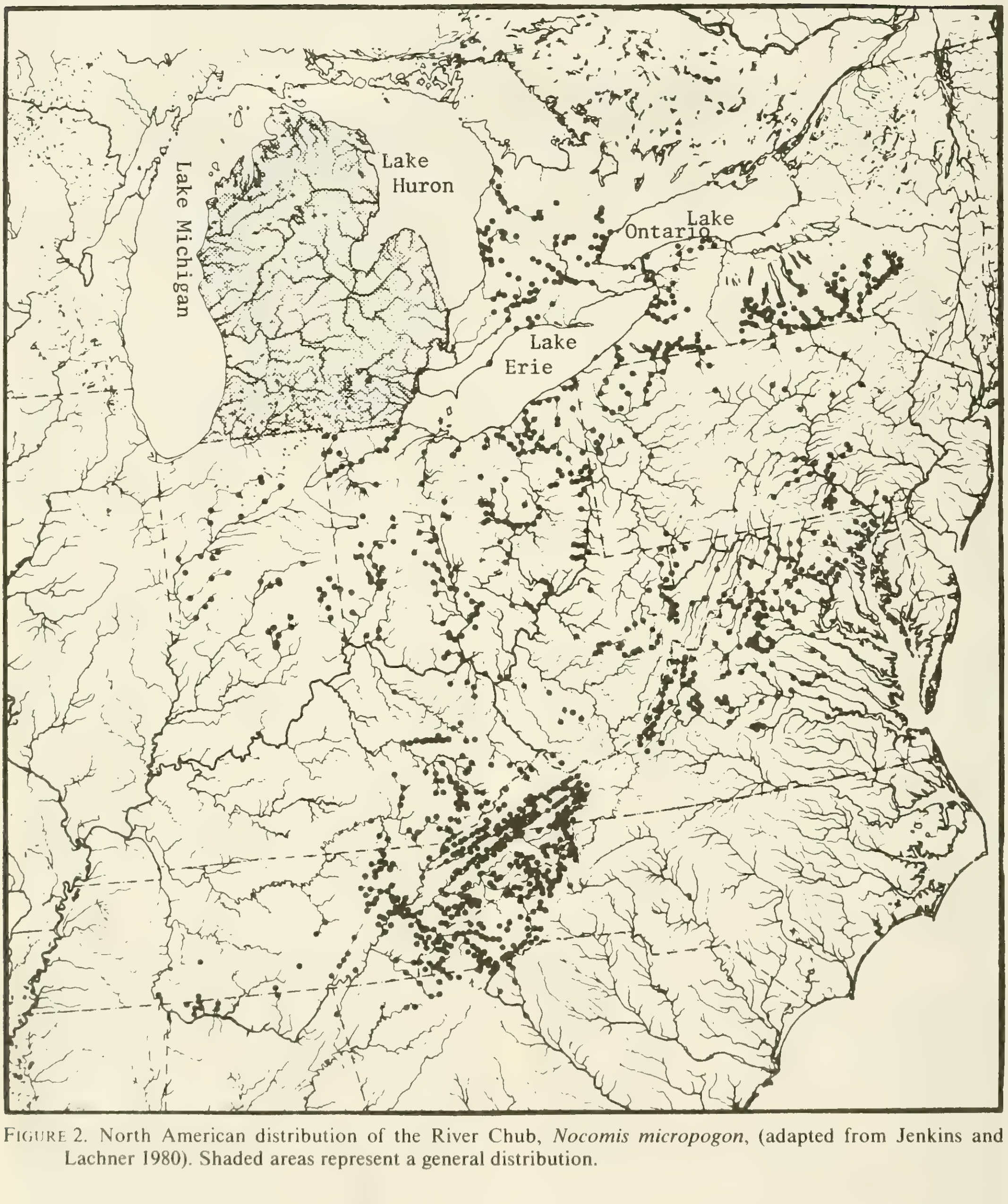

FIGURE 2. North American distribution of the River Chub, *Nocomis micropogon*, (adapted from Jenkins and Lachner 1980). Shaded areas represent a general distribution.

colonization for possible range extensions through northern Ontario and north-western Quebec. The River Chub nest-building habits could affect the forage minnow populations in any newly settled territory.

Incidental collections were made by ROM in 1985 while assessing Gravel Chub (*Hybopsis x-punctata*) populations of the Thames River between Muncey and London (Holm and Crossman 1986a). These collections provide strong evidence for the continued existence of the River Chub in there.

Additional incidental collections were made in the Saugeen River in a 1985 ROM survey for Redside Dace (*Clinostomus elongatus*) (Holm and Crossman 1986b). These collections indicate the presence of River Chub in large numbers in the Saugeen River watershed.

Other than collections mentioned above, there has been little effort extended in determination of

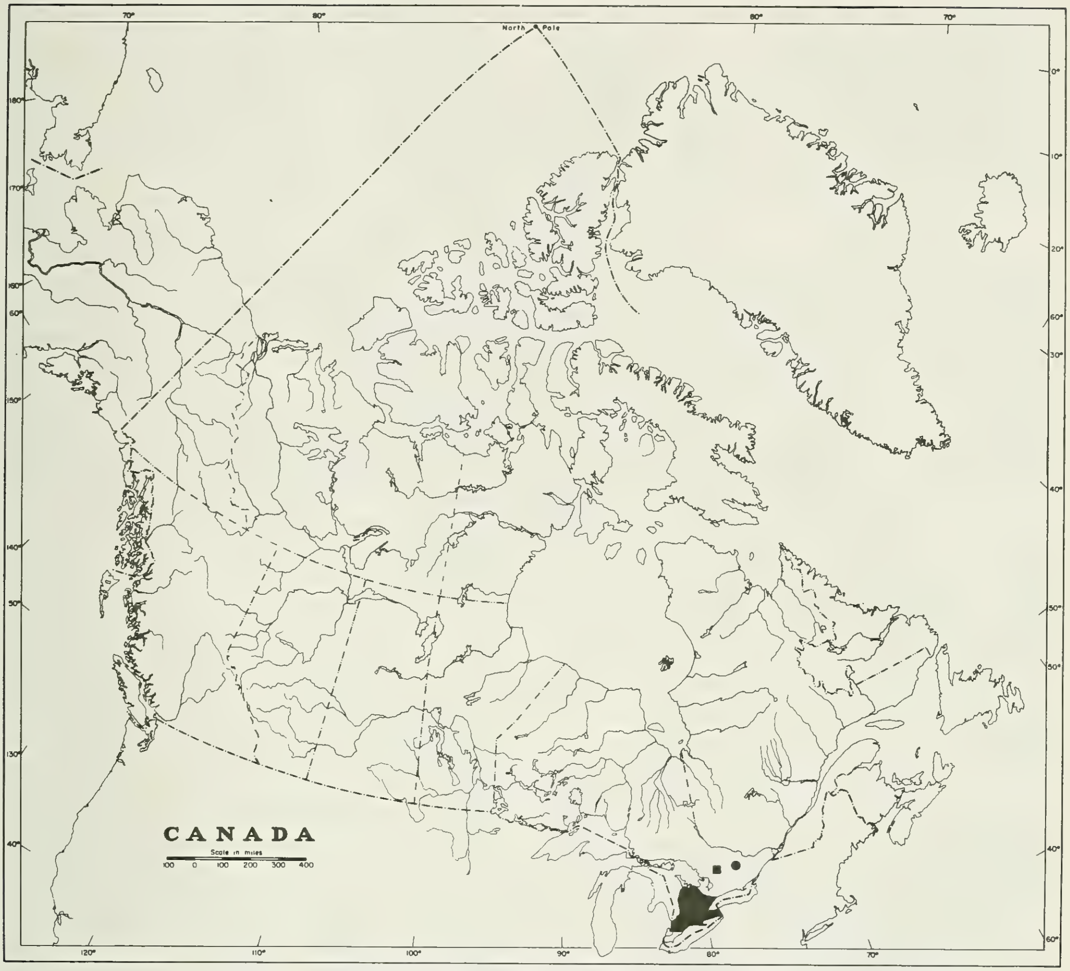

FIGURE 3. Canadian distribution of the River Chub, *Nocomis micropogon*.

the status of the River Chub since 1976. This probably reflects a reduced emphasis in Ontario on stream inventory surveys since the mid-1970s. Stream assessment efforts will resume in the next few years (G. Gale, OMNR, Toronto, personal communication).

The size and health of the various River Chub populations can only be evaluated by direct effort to survey for the species followed by statistical analysis. Nevertheless, the information available does indicate that the River Chub is still common and occupying its known range in Ontario.

General Biology

Young River Chub feed on algae and zooplankton. As they grow, the fish eat progressively larger foods, such as aquatic insect larvae, microcrustaceans, molluscs, plants, crayfish and possibly some fish (Scott and Crossman 1973; Jenkins and Lachner 1980).

In the spring, the males build nests of stones and gravel in rivers moving slowly enough to not impede nest construction. The water is usually from 46 to 61 cm deep, though occasionally it may be up to 90 cm deep (Reighard 1943). A circular depression is first excavated and cleared of all sand and fine gravel. The male fish then fills the site with newly gathered stones and continues piling stones and other large bottom debris until a large, domelike pile has been made (Reighard 1943; Lachner 1952; Scott and Crossman 1973). For each individual spawning act, the male digs a shallow trough, in which the eggs are deposited and fertilized. The male fish fills each trough with small stones and pebbles immediately after the spawning act (Reighard 1943; Scott and Crossman 1973). The eggs are afforded some protection from predatory fish, such as the Hognose Sucker (*Hypentelium nigricans*) by falling between the stones of the nest (Reighard 1943; Lachner 1952).

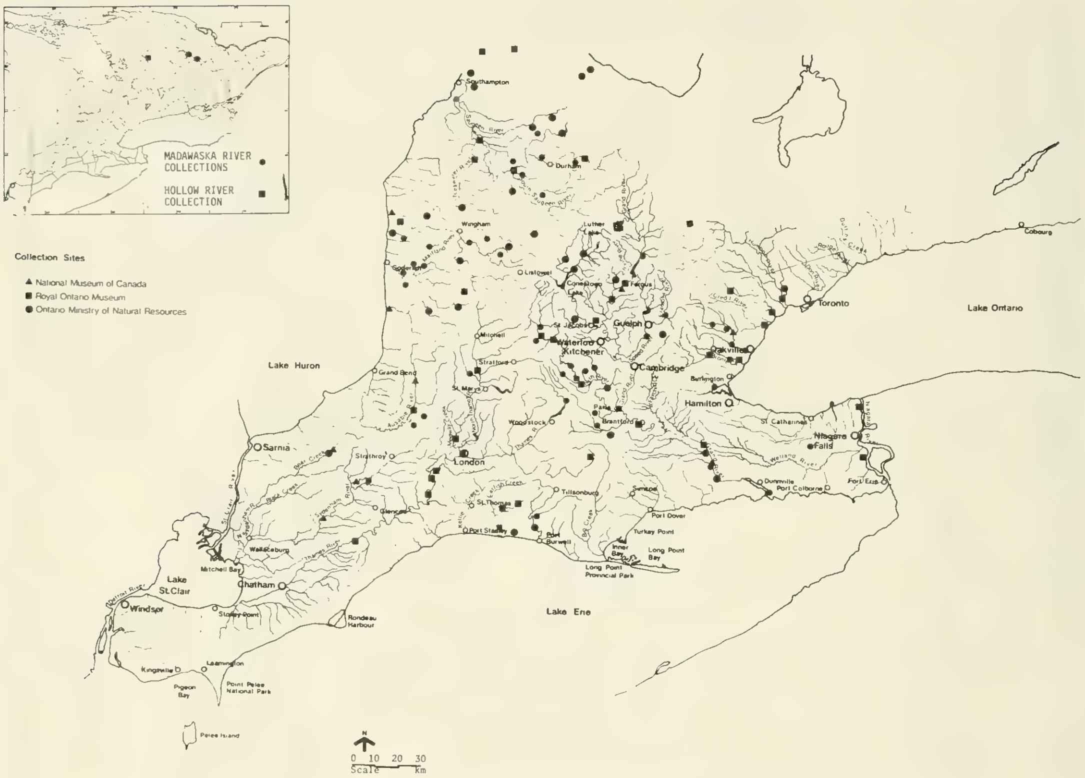

FIGURE 4. General location of collection records for *Nocomis micropogon* in Ontario.

Congregations of many species of fish can occur over River Chub nests and other minnow species have been observed spawning upon these gravel mounds (Reighard 1943; Tsai and Zeisel 1969; Scott and Crossman 1973). These include the Common Shiner, *Notropis cornutus*, and the Longnose Dace, *Rhinichthys cataractae*, (Raney 1940; Cooper 1980). Longnose Dace x River Chub hybrids were collected by Raney (1940). The author hypothesized that the hybrids resulted from accidental cross-fertilization above a River Chub nest. The use of River Chub nests by other species has been attributed to scarcities of suitable breeding areas (Tsai and Zeisel 1969; Cooper 1980). On the other hand it may be a kind of nest parasitism where the parasite takes advantage of superior spawning sites prepared by the host without having to expend energy in nest construction.

Each of the associated species observed by Reighard (1943) [Rosyface Shiner, *Notropis rubellus*, Common Shiner, and Central Stoneroller, *Campostoma anomalum*] spawned in species-specific areas over River Chub nests. In this case, all 6 interspecific hybridizations were possible, though out of 12 possible reciprocal crosses, Reighard (1943) logically determined that only 8 were probable and the other 4 were unlikely.

Although Cooper (1980) did not observe simultaneous spawning of Longnose Dace and River Chub, eggs of both species which he collected from the same nests were close in development. This may indicate that the spawning events of each of the two species had occurred at close to the same time, perhaps because the Longnose Dace do not spawn until nest building activity has stopped. Of course, this is also when the River Chub spawn.

These fish grow at a uniform rate throughout their life and are sexually mature at about 3 years of age (Lachner 1952). Their lifespan can reach 5 years, though few live more than 3 summers (Lachner 1952; Scott and Crossman 1973). Cooper (1980) provides detailed information on the development of River Chub. Buynak and Mohr (1980) give keys for distinguishing post-larvae and late post-larvae specimens of River Chub, Cutlips Minnow (*Exoglossum maxillingua*) and Stonerollers.

Three-year-old specimens collected from the Lake Huron drainage by Scott and Crossman

(1973) were from 104 mm to 110 mm. The males tend to grow faster, and to greater size than the females (Lachner 1952; Scott and Crossman 1973). Figures for standard lengths at various ages for *Nocomis micropogon* specimens from the Lake Huron drainage are given by Scott and Crossman (1973).

Hornyhead Chub are virtually indistinguishable from River Chub, except at breeding season (Lachner 1952; Ferguson et al. 1980). At this time of year, the species differ morphologically mainly in the number and pattern of nuptial tubercles present on breeding males (Ferguson et al. 1980). The heads of River Chub swell up to form large humps but this does not occur in the Hornyhead Chub. Males of both chub species develop brilliant breeding colours which can be used to distinguish the two species as well as the two sexes within each species; detailed descriptions can be found in Lachner (1952). In southern Ontario, the two minnows share many morphological, ecological and life history features, and often live in the same rivers, but the two species do not seem to interbreed often (Scott and Crossman 1973; Ferguson et al. 1980).

Based on tuberculation, body size attained, and pharyngeal dentition, Lachner and Jenkins (1967) felt that *Nocomis biguttatus* is the most primitive species in the genus and may have given rise to *Nocomis micropogon*, as well as to other species. A general evolutionary trend among the Cyprinidae is a reduction of tooth numbers. This is noticeable between the *Nocomis biguttatus* and *Nocomis micropogon* species. Other trends, correlated to nest building, may be the larger body size of *Nocomis micropogon* and the development of the head tubercles (Lachner and Jenkins 1967). Information gathered in a biochemical study by Ferguson et al. (1980) confirms that *Nocomis micropogon* and *Nocomis biguttatus* are separate, but sibling species.

Trematodes (*Gyrodactylus* sp., *Neascus* sp., *Neascus vancleavi*) and a nematode (*Agamonema* sp.) have been reported as parasites of River Chub (Scott and Crossman 1973).

Limiting Factors

River Chub require clean, clear water. Siltation from land development and from erosion of cleared farmland may reduce the range and abundance of the species (Lachner and Jenkins 1967). Lachner and Jenkins (1967) also listed stream gradient, turbidity, and coal mine pollution as probable restrictions on the distribution and abundance of *Nocomis micropogon* in the southeastern Ohio River basin and the Tennessee River drainage. Lachner and Jenkins (1971) stated that large, turbid rivers can act both as barriers and/or as direct, but limited, pathways to dispersion of clear-water, small-stream fishes.

The range extension in the Madawaska River of eastern Ontario may be a route to further dispersion of River Chub both downstream and upstream of the Madawaska's entrance into the Ottawa River at Arnprior, where not prohibited by dams.

Special Significance of the Species

River Chub can grow to lengths of over 20 cm and could possibly be used as food in Canada as they have been in parts of the United States (Scott and Crossman 1973), but this is unlikely. Hornyhead Chub and River Chub have been equally important as bait minnows and when used as bait, dealers and anglers probably do not distinguish these chubs from the more prevalent Creek Chub, *Semotilus atromaculatus*, (Scott and Crossman 1973).

In southern Ontario, River and Hornyhead chub occur both sympatrically and allopatrically. Even though these minnows have very similar ecological and life history features (Scott and Crossman 1973), and often live in the same waters, the two do not seem to interbreed often. This anomaly suggests a productive area for the study of the mechanisms involved in species recognition, reproductive isolation and ecological separation (Ferguson et al. 1980).

River Chub are known to build large rocky nests, suitable for the spawning activities of themselves and other forage minnow species. Lachner (1952) has suggested that the use of River Chub nests by other fish may be economically important in maintaining a large supply of forage minnows.

Nocomis micropogon may be able to use the Ottawa River as an avenue of colonization for possible range extensions in eastern and northern Ontario and western Quebec (Lachner and Jenkins 1971). Such an event could affect the forage minnow populations of any new range extensions because of the nest-building habits of the River Chub. Most, or all, sport fish are piscivorous to some degree. Changes in forage minnow abundance could affect the population and sizes attained of sport fish. Monitoring and studying this unique situation may yield a great deal of valuable ecological, and economical, information.

Evaluation

River Chubs are widely distributed across southern Ontario form Georgian Bay south to Lake Erie, and appear to be colonizing the Ottawa River system where they may have been introduced by an accidental release of bait fishes. The species has also been recently confirmed from the Hollow River in central Ontario.

Based on the evidence presented, the River Chub seems to have maintained its presence in its traditional southwestern Ontario range and appears to be expanding into other Ontario watersheds. The species does not appear to be in jeopardy in Canada and does not meet the criteria for listing in a COSEWIC category.

Acknowledgments

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Status of the Umatilla Dace, *Rhinichthys umatilla*, in Canada*

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Hughes, G. W., and A. E. Peden. 1989. Status of the Umatilla Dace, *Rhinichthys umatilla*, in Canada. Canadian Field-Naturalist 103(2): 193–200.

Populations of *Rhinichthys umatilla* (Umatilla Dace) in the Similkameen, Kettle, Columbia, Slocan and Kootenay river drainages represent the only known occurrences of the species in Canada. Morphological differences between populations are apparent. Although primarily inhabiting non-impounded rivers, the species also occurs in sympatry with *R. falcatus* (Leopard Dace) in current areas of reservoirs of the Kootenay River. The Columbia River will probably be affected in the future by a new hydroelectric dam project, which would reduce available riverine habitat. At this time, no major projects are known to be planned which would further affect the Similkameen or Kettle rivers in Canada or Washington State. Because of its scarcity in Canadian portions of the latter two rivers and the impact of reservoirs on the Columbia and Kootenay rivers, we believe that *Rhinichthys umatilla* is a rare species in Canada.

Au Canada, *Rhinichthys umatilla* ne se rencontre que dans les bassins des rivières Similkameen, Kettle, Slocan et Kootenay et du fleuve Columbia. Les différences morphologiques entre ces différentes populations sont apparentes. Au Canada, l'espèce habite surtout des cours d'eau à écoulement libre, mais on la rencontre aussi en sympatrie avec *R. falcatus* dans les zones à courants du réservoir de la rivière Kootenay. On projette d'aménager un nouveau barrage hydro-électrique sur le fleuve Columbia, ce qui risque d'y restreindre, dans l'avenir, l'habitat disponible. Aucun projet d'importance susceptible de modifier plus avant les habitats des rivières Similkameen ou Kettle, au Canada ou dans l'état de Washington, n'est prévu pour l'instant. Vu sa rareté dans les sections canadiennes de ces deux rivières et des effets des réservoirs du Columbia et de la Kootenay, nous croyons que *Rhinichthys umatilla* devrait, au moins, recevoir le statut d'espèce rare.

Key Words: Umatilla Dace, *Rhinichthys umatilla*, Leopard Dace, *Rhinichthys falcatus*, cyprinids, minnows, rare fishes, British Columbia, Oregon, Washington.

The Umatilla Dace, *Rhinichthys umatilla*, belongs to a genus containing other species and subspecies considered to be endangered or threatened in North America (Deacon et al. 1979; Campbell 1987; Johnson 1987). In addition, taxonomy and the relationship to other dace species is not completely understood. The species is poorly known and is not listed in some common references to fish faunas (*see* Scott and Crossman 1973; Lee et al. 1980; Robins et al. 1980).

Although variable between Canadian drainages, the populations are distinct from other species of *Rhinichthys* but superficially similar to the Leopard Dace (*R. falcatus*) and Speckled Dace (*R. osculus*). Morphologically, the species most closely resembles the Leopard Dace, from which it differs in pigmentation and the number of scales in the lateral line. The body is elongate and averages about 7 to 8 cm in length (Figure 1). There is a small barbel at each corner of the mouth; this barbel is absent in the Speckled Dace. These dace are light in colour, creamy on the sides, somewhat darker on the back and head. Irregular dark spots may be present over the body. The pelvic fins may become more highly coloured (orange to red) in breeding males.

Distribution

Rhinichthys umatilla is known from the type locality of the Columbia River at Umatilla, Oregon, and we have examined specimens collected throughout the Columbia drainage from the Bonneville Dam to British Columbia (Figure 2). The species probably occurs in rivers of northern Oregon and the Snake River of Idaho but populations in these areas require further study. Within Canada, the species is known from populations in the Similkameen, Kettle, Columbia and Kootenay rivers and the mouth of the Slocan River.

Canadian populations differ in scale counts and morphometrics; these differences suggest that the populations may be isolated from each other. The species has a preference for riverine habitat with cobble and stone cover, and therefore the habitat of Roosevelt Lake in Washington may deter passage between the Similkameen, Kettle and Columbia rivers. Thirty kilometers downstream of the international boundary on the Similkameen River are impassable falls. Consequently, upstream populations in the upper United States and Canadian reaches are isolated from down-

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*Rare status assigned by COSEWIC April 1988.

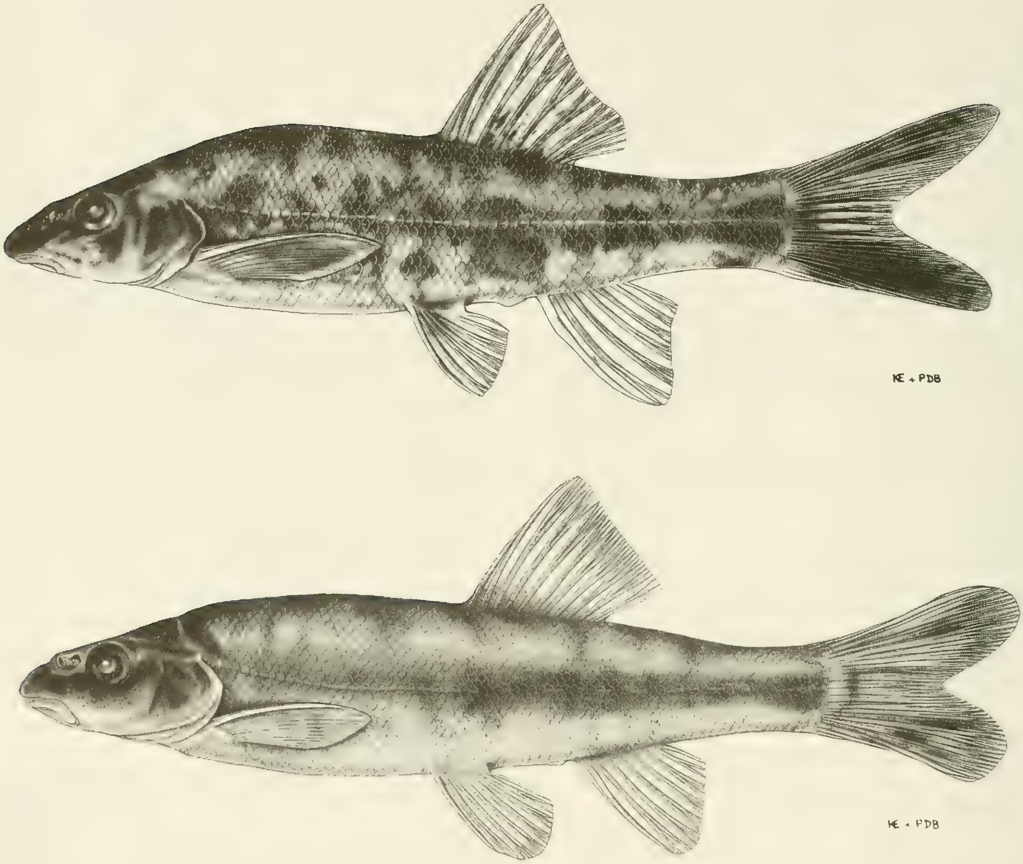

FIGURE 1. Illustrations of *Rhinichthys umatilla* from (a) Kettle River (72 mm SL, BCPM *983-16890*, and (b) Otter Creek (58 mm SL, BCPM *983-1663*). Drawings by Karen Udall-Ekman.

stream Similkameen, Okanogan and lower Columbia populations.

In the Kettle River, upstream dispersal into the habitat occupied by *R. osculus* is prevented by impassable falls at Cascade, B.C., and the species is limited in Canada to the area between Cascade and the international boundary, a distance of approximately 5 km. Known distribution in the Columbia and Kootenay river system extends to the reservoir above South Slocan Dam (Figure 3). Before the reservoirs were constructed, we suspect the steep river gradient at Bonnington Falls may have separated downstream fishes (*R. umatilla*, *Cottus bairdi* (Mottled Sculpin) and *C. confusus* (Shorthead Sculpin)) from the cool water fauna of Kootenay Lake (i.e., *C. cognatus* (Slimy Sculpin)).

The Arrow Lakes may impede upstream dispersal of riverine inhabiting *Rhinichthys umatilla*, although its congener, *R. falcatus*, has dispersed into the lake. Although *R. umatilla* is not known above the mouth of the Slocan River, there appears to be no obstacle to dispersal upstream as far as the mouth of Slocan Lake. On the other hand, it is unlikely to penetrate that lake and its coldwater tributaries.

Although rare in the Canadian portion of the Similkameen River, *R. umatilla* has penetrated about 112 km of riverine habitat to Otter Creek. Chilled waters of higher mountain elevations and/or waterfalls apparently limit further upstream dispersal in the Tulameen and Similkameen rivers. Post-glacial dispersal routes via Otter Creek, Okanogan Lake and the Arrow lakes has been discussed by McPhail et al. (1986).

Protection

No specific legislation protects this species in British Columbia, although regulations govern the collecting and transport of fishes within the province. Provincial water quality pollution control regulations are designed to maintain water quality at acceptable levels.

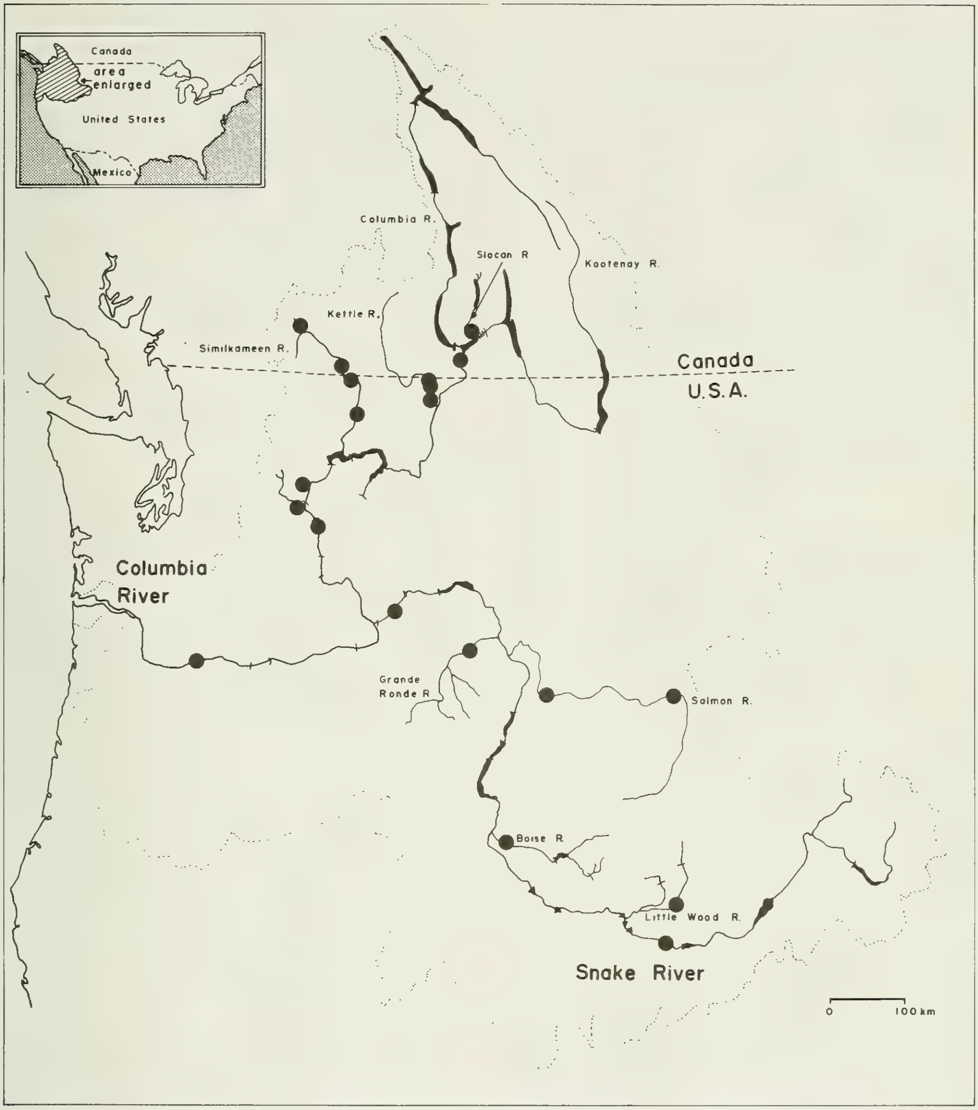

FIGURE 2. Distribution of *Rhinichthys umatilla* based on specimens examined in this study.

Population Size and Trends

Numbers of *R. umatilla* collected from various Canadian drainages are listed in Table 1. Otter Creek below Otter Lake, the Kettle River below Cascade, the Columbia River between Castlegar and Blueberry Creek, and the Kootenay River above Brilliant were surveyed and sampled by water access. Other Columbia River and Similkameen River collections were made at road access points.

With the exception of 20 large (more than 40 mm) specimens from Otter Creek, only 13 adults have been taken in British Columbia. However, the capture of juveniles from nearshore habitat suggests reproductive success in the lower Similkameen, Kettle, Kootenay and Columbia waters within the province. The location of concentrations of breeding adults in Canada is not known, however, upstream migrations of fish from the U.S. could be affecting the population size and success on the Similkameen and Kettle rivers.

Juveniles have been found near adults in the Columbia and Kettle rivers of Canada and the Similkameen River just south of the international border between Nighthawk and Oroville, USA. No juveniles were found with the larger fish (35.4 to

75.7 mm SL (standard length)) in Otter Creek; this finding suggests that reproduction is not successful there. The sex ratio of Otter Creek adults was 6 females: 0 males: 4 undetermined (either released alive or kept for illustration) and this apparent lack of males suggests possible impairment of reproductive potential.

Evidence for the stability of populations is nonexistent. However, eleven *R. umatilla* were collected in 1956 from Otter Creek and one from the Similkameen River above Similkameen Falls, Washington, in 1963, indicating that the species has occurred in the Similkameen drainage for at least 29 years. No collections of *R. umatilla* from the Canadian portion of the Columbia or Kettle rivers previous to our sampling are known to us.

Habitat

Suitable habitat appears to be widespread in the Columbia River below Castlegar, although only three of the 11 sample locations with juveniles yielded specimens larger than 40 mm SL (N=3) after over 11 300 seconds of electrofishing. Modification of river flow on the Columbia (Figure 4) by damming has moderated freshet runoff conditions and may have affected the ability of the species to sustain themselves in the river downstream from the Keenleyside dam at Castlegar.

The Murphy Creek Dam on the Columbia River proposed by B.C. Hydro (B.C. Hydro and Power Authority 1984) would result in the conversion of 34 km of the Columbia from riverine to reservoir habitat downstream of the Arrow Lake and Kootenay River reservoirs. B.C. Hydro's application for an Energy Project Certificate (B.C. Hydro and Power Authority 1984) proposes that power would be available from the Murphy Creek Project in 1995, although economic conditions have since resulted in the deferment of construction until demand for electricity warrants additional power supply. Recent Canada-U.S. agreements on free trade may reopen the project.

Just recently (October 1987) we found substantial populations in the reservoir on the Kootenay River above the Brilliant Dam, in

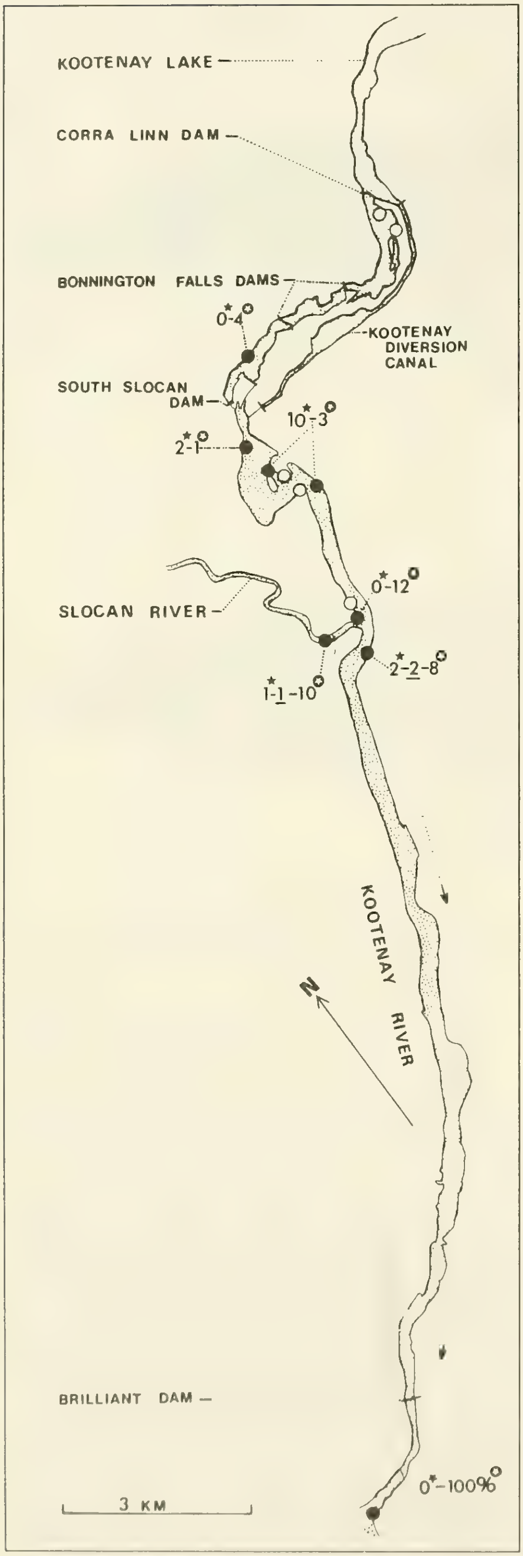

FIGURE 3. Locations of dace collections in reservoirs of the Kootenay River showing sympatry of specimens diagnosed as *Rhinichthys umatilla* and *R. falcatus*. Large white circles = samples where neither species was collected. Sample sizes of *R. falcatus* indicated by numbers with black stars. Sample sizes of *R. umatilla* indicated by numbers with small dark spots having white star in centre. Sample sizes of intermediates are underlined. Dotted arrows indicate direction of river flow.

TABLE 1. Collections of *Rhinichthys umatilla* from Canada.

	Size	
Locality	> 40 mm SL	< 40 mm SL
Similkameen River	11	20
Kettle River	13	2
Columbia River	200*	20*

*approximate.

addition to four juveniles above the South Slocan Dam. These artificial habitats with shorelines flooding during seasons when water levels are normally low must have an impact on dace populations and such effects need further study. A few sympatric *Rhinichthys falcatus* were also found here (Figure 3) and studies on species interactions are needed in this artificial habitat. Both the Kootenay and Columbia rivers possess large stretches of large, rounded and polished stones for which sediment is probably washed away by current during floods. We suspect interspaces between rocks allow refuge for larger *R. umatilla* along river banks at varying water levels.

In particular, such habitats (especially those near Trail) can have a dense film of green algae covering rocks during summer and fall, indicating a potentially productive food base. Although such habitats yielded many juvenile *R. umatilla* to our electroshocker, we were unable to sample deeper swift waters safely, where large *R. umatilla* may occur.

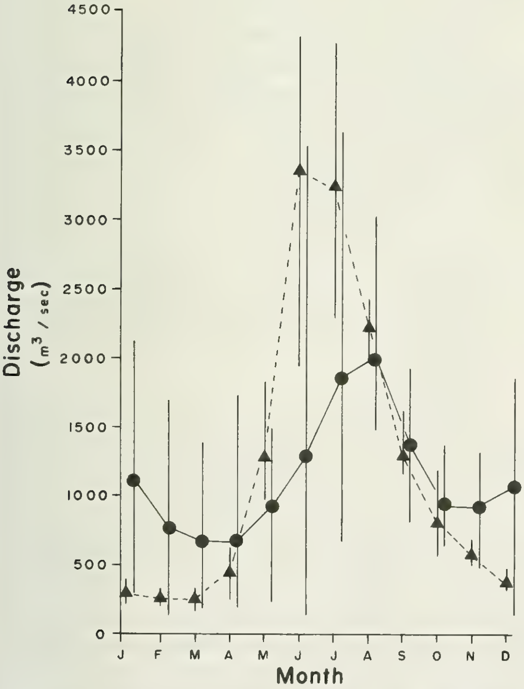

FIGURE 4. A comparison of Columbia River flow rates at Castlegar before (triangles) and after (dots) dam construction in 1968.

In the British Columbia section of the Kettle River very little habitat is available due to a lack of cobble and stone cover for much of the length below Cascade (*see* Peden and Hughes 1981). Only the "rockpile" at Cascade appears to offer interspaces large enough for adult cover and possible breeding habitat. Further downstream, sand or stones on sand offer little cover for adults or juveniles near the Canada-U.S. border. A comparatively large section of the Kettle River south of the international boundary offers suitable cobble and stone habitat and *R. umatilla* has been found in abundance as far south as Barstow over 30 km downstream.

Canadian sections of the Similkameen River in which we captured juveniles are similar to habitat where we collected adults between Nighthawk and Oroville, USA, but Canadian samples of adults have only been taken at Otter Creek (*see* McPhail and Lindsey 1986). Here the habitat appears quite different from that of the nearby Tulameen River, a tributary of Similkameen. Otter Creek is fed by the surface water of Otter Lake and is relatively warm in summer and seemingly productive, based on presence of algal cover in contrast to that observed in the Tulameen. Permanent concentrations of adults must be found in the Similkameen in order to make any judgement on the health of Canadian populations in this river.

Anticipated increased use of water for industrial, agricultural and domestic purposes will probably cause minor changes in water quality of the Similkameen and Kettle rivers when compared with the potential habitat alterations of the Murphy Creek Development on the Columbia River. At present, we know of no future dams planned for the Similkameen or the Kettle rivers.

In general, *R. umatilla* is most easily captured from the cover provided by cobble and stones in areas of current which is fast enough to prevent siltation and are usually found along river banks at depths of less than 1 m.

General Biology

Very little is known about the biology of *R. umatilla*. Size frequency histograms (Figure 5) suggest that young of the year are generally smaller than 40 mm. Larger fish are presumably at least one year old but the life span and growth rates of adults have not been determined.

The reproductive biology of *R. umatilla* has not been investigated. Breeding probably occurs in late

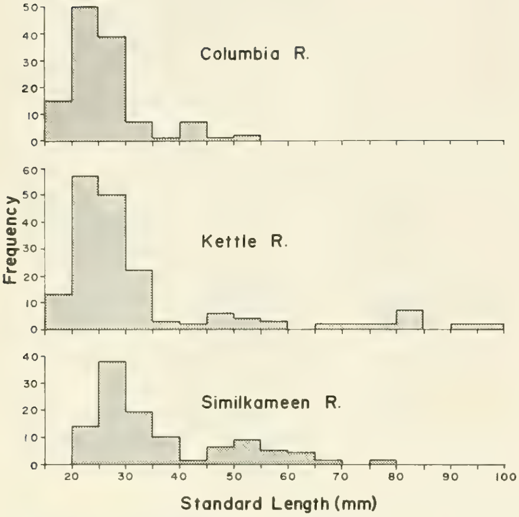

FIGURE 5. Length frequency histograms based on fish collected during spring and fall in the Columbia River, B.C., and in upper Washington and Canadian reaches of the Kettle and Similkameen rivers.

spring and summer if similar to that of *R. falcatus*, *R. cataractae* (Carlander 1969) and *R. osculus* (Wydoski and Whitney 1979; Peden and Hughes 1981).

The occurrence of the species near Castlegar, Trail and the reservoirs of the Kootenay River suggests that the species can tolerate some degree of human disturbance, although the adaptability to change has not been investigated.

Limiting Factors

The restricted distribution of the *R. umatilla* in Canada renders it susceptible to population reduction should water quality deteriorate. The presumed preference for cobble and stone habitat with enough current to remove silt could be adversely affected by the changing of riverine to reservoir habitat, siltation from dam construction or run off, or by an increase in water withdrawal and pollutants from industrial, agricultural or domestic uses. In the Kootenay reservoirs, shallow areas still have steady river flow, which possibly facilitates species survival in contrast to fluctuation of water level and current (or its absence) in large storage reservoirs such as the Arrow Lakes. Presumably, the species prefers relatively productive low-elevation waters, where food may be more abundant than in the colder, unproductive water of higher elevations.

Competition for food by other benthic fish species and predation may also limit population size; however, there is no evidence known to us which would suggest that these factors are likely to vary to an extent that would cause a change in the population size of *R. umatilla*. In the habitats of the Similkameen and Kootenay rivers with sympatric *R. falcatus*, *R. umatilla* appears more numerous and prefers stronger current. Otherwise, sculpins (*Cottus*) and Longnose Dace (*R. cataractae*) appear to be the dominant potential competitors.

Special Significance of the Species

Although variable between Canadian drainages, the populations of *R. umatilla* are distinct from other *Rhinichthys* species (Table 2). Since *R. umatilla* is similar to *R. falcatus* and *R. osculus*, evidence of reproductive isolation was drawn from the sympatric occurrence of *R. falcatus* and *R. umatilla* in the Similkameen River and Kootenay River, and *R. osculus* and *R. umatilla* in the Kettle River. The morphological and pigmentary differences found between populations suggest possible unique adaptation to specific habitats.

In October 1987 we obtained sympatric *R. umatilla* and *R. falcatus* in the reservoir between the Brilliant and South Slocan dams on the Kootenay River (Figure 3). We applied a character index described by Peden and Hughes (1988) to these sympatric fish within the reservoir and diagnosed 13 *R. falcatus* and 34 *R. umatilla* plus four possible intermediates (Figure 6). However, some features such as shape of the barbel were quite variable and suggested that some genetic introgression may have occurred. Sample sizes were not large enough to evaluate eye or nostril sizes, which appear larger on many *R. falcatus*. This situation requires further study to judge the degree of species isolation. Further evidence for sympatry of *R. umatilla* with its congeners in the Similkameen, Kettle and Kootenay rivers and discussion of the status of *R. umatilla* as a valid species is available in Peden and Hughes (1988).

Evaluation

R. umatilla should be considered rare in Canada based upon its naturally restricted distribution and sparse abundance. In the Columbia and Kootenay rivers the species is more numerous but is threatened by dam construction or unsuitable water flow when water levels are manipulated for power or flood control. The restricted amount of Canadian habitat in the Kettle River below Cascade (1 to 2 km) suggests that this population may depend on immigrants from United States segments of this river; however, the hugh still water habitat of the Roosevelt Reservoir in Washington probably hinders dispersal from farther down river. The presence of impassable falls on the

TABLE 2. Range of diagnostic counts and measurements of *Rhinichthys umatilla*, *Rhinichthys falcatus* and *Rhinichthys osculus*. (Canadian samples supplemented by specimens from nearby downstream populations in Washington State.)

	Species						
	R. umatilla				*R. falcatus*		*R. osculus*
Characteristic	Otter	Similkameen	Kettle	Columbia	Similkameen	Other[1]	Kettle
Lateral line pores							
Mean	66.4	62.8	61.0	65.6	55.8	56.1	63.4
Range	61-72	57-71	55-69	60-71	49-62	51-66	59-69
Number	20	52	38	28	27	95	23
Scales around caudal peduncle							
Mean	36.9	35.0	34.1	34.9	29.0	26.9	30.4
Range	33-40	32-39	29-39	31-39	25-33	20-32	27-33
Number	20	51	17	28	27	94	23
Total vertebrae							
Mean	40.7	40.7	40.2	41.4	41.3	40.8	38.4
Range	40-42	39-42	39-41	40-43	40-42	40-43	38-40
Number	16	54	30	25	26	17	20
Standard Length							
Range (mm)	35-76	20-52	23-98	24-53	19-96	29-77	23-55
Number	21	71	46	39	35	99	33
Snout overhang Ratio*							
Mean	103	117	119	118	109	103	57
Range	82-125	80-167	90-152	88-163	72-147	73-129	42-67
Number	17	59	34	39	41	32	30
Caudal depth Ratio**							
Mean	115	106	117	109	86	88	112
Range	102-138	95-116	106-133	92-124	76-94	80-96	101-126
Number	20	66	33	39	31	32	30
Maxillary Barbel	Usually small and rounded				Usually large and flattened		Usually absent

[1]refers to specimens from Columbia and Fraser populations combined to contrast with Simikameen collections
* snout to tip of lower jax × 1000/Head length. ** caudal depth × 1000/SL.

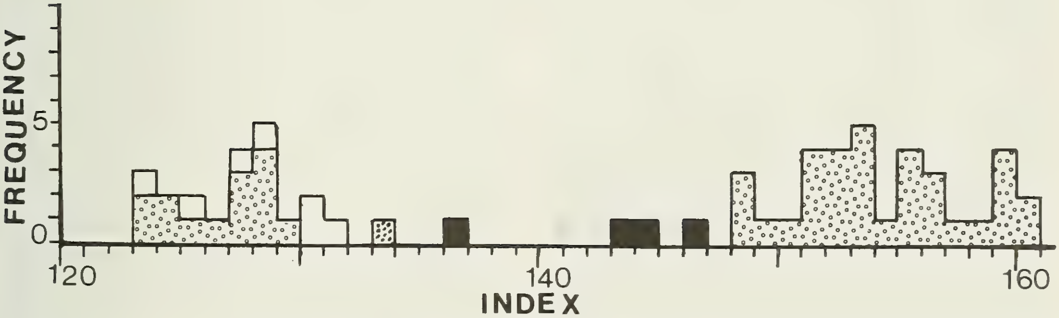

FIGURE 6. Character index indicating *Rhinichthys falcatus* (individuals sorting out between 123 and 133) and *Rhinichthys umatilla* (between 148 and 160). Darkened bars = apparent intermediate individuals. Individual with value of 133 is an atypical *Rhinichthys falcatus* from the Slocan River. Light coloured bars = allopatric *Rhinichthys falcatus* from lower Arrow Lake. All other individuals (stippled) are sympatric individuals from localities in the reservoir between the Brilliant and South Slocan dams on the Kootenay and mouth of the Slocan rivers.

Similkameen River 30 km downstream of the Canadian border suggest that the population is not likely to be substantially supplemented from populations in downstream reaches of the Similkameen or Okayagan rivers.

Acknowledgements

This report is the result of field work conducted by Alex Peden, Grant Hughes, Gordon Green and Cris Guppy of the Royal British Columbia Museum from 1979 to 1987 in southern British Columbia. Alex Peden supervised the gathering of data and the drafting of this report, which was prepared by Grant Hughes. R. Carveth, University of British Columbia, provided specimen loans of *R. umatilla* and *R. falcatus* and J. D. McPhail, University of British Columbia, contributed much valuable information regarding British Columbia *Rhinichthys*. Sam Wright, State of Washington Department of Game, provided permits for the collection of fishes from Washington. Specimens from Bonneville were provided on loan by the California Academy of Sciences, and C. E. Bond, Oregon State University, courteously provided information about Oregon State specimens.

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Status of the Redfin Shiner, *Notropis umbratilis*, in Canada*

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The Redfin Shiner (*Notropis umbratilis*) has a wider and more longstanding distribution in Ontario than previously thought, although sufficient data to establish population sizes and trends are still lacking. Redfin Shiners are variable in their habitat preferences, but commonly occur among submerged aquatic vegetation in deep, quiet pools of low to moderate gradient streams of small to medium size, which have normally clear, but sometimes turbid, warm waters and sandy or gravelly bottoms. The species matures in one year and is typically short-lived. Spawning usually occurs over the nests of certain *Lepomis* species. The first stages of stream degradation favour the species and known populations do not appear threatened. However, more severe watershed deterioration appears eventually to preclude them. The species is restricted in its Canadian distribution and generally occurs in low numbers, but populations are stable and reproducing. Designating the species as rare does not appear warranted.

En Ontario, le méné d'ombre (*Notropis umbratilis*) serait plus répandue qu'on ne l'aurait cru dans la province et y serait établie depuis longtemps. À l'heure actuelle, on ne dispose pas de données suffisantes permettant d'établir la taille de ses populations et ses tendances démographiques. Bien que leur préférence en matière d'habitat soit variable, le méné d'ombre préfère la végétation aquatique submergée des étangs profonds et calmes associés aux cours d'eau de taille petite à moyenne, dont la pente est de faible à moyenne et dont les eaux sont généralement claires mais parfois troublées, chaudes et les fonds sableux ou graveleux. Le méné d'ombre a, en général, une courte espérance de vie et atteint la maturité au bout d'un an. Ce poisson fraie en général dans les nids de certaines espèces de *Lepomis*. Les premiers stades de dégradation des cours d'eau favorisent l'espèce. Les populations identifiées ne semblent donc pas menacées. Toutefois, une dégradation plus grave des bassins versants semble finalement mortelle pour eux. La répartition de l'espèce est restreinte au Canada, ses effectifs sont généralement limités mais il ne semble pas justifié de considérer l'espèce comme rare.

Key Words: Redfin Shiner, *Notropis umbratilis*, distribution, Ontario, biology, ecology, reproduction, life history, habitat, population size and trends.

The Redfin Shiner (*Notropis umbratilis*, Girard 1857) is a small, deep-bodied minnow with a blunt snout (Figure 1). Maximum length is about 88 mm (Eddy and Underhill 1974; Trautman 1981), but it seldom exceeds 64 mm in Ontario (Scott 1967; Scott and Crossman 1973). Non-breeding males and females are both pale olive to brownish-blue above, tending towards silvery or milk-white below. Faint saddle-bands, chevron-shaped and varying in number, straddle the back. A dark blotch occurs at the base of the anterior dorsal fin rays, a dusky stripe along the midline. The fins of non-breeding specimens are transparent, sometimes dusky gray or tinged with blue or silver. Scales from the pre-dorsal area are inconspicuous due to their small size and lack of dark margins. The segmental blood vessels show through the skin of the upper sides anterior to the dorsal fin.

During breeding, males become steel- to brownish-blue, more intensely so atop the head. Fine tubercules develop over much of their bodies and the paired fins. The lower fins of males, particularly the caudal and anal, flush with contrasting dusky to bright red coloration. The species' common name in the northwest, the "bloodtailed shiner" (Raney 1969), reflects this caudal colouration. In males, body compression, arching of the nape and flushing of the irises often occur. The chevron markings may also become more obvious. In contrast, breeding females remain relatively drab, changing little but for the occasional growth of a few tubercles.

Details of description, morphology, meristics, sex differences, and distinguishing characteristics may be found elsewhere (Fowler 1910; Forbes and Richardson 1920; Eddy and Surber 1947; Eddy 1957; Moore 1957; Cook 1959; Clay 1962; Cross 1967; Snelson 1972, 1973; Miller and Robison 1973; Scott and Crossman 1973; Eddy and Underhill 1974; Cross and Collins 1975; Pflieger 1975; Snelson and Pflieger 1975; Smith 1979; Trautman 1981; Auer 1982; Becker 1983; Robison

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*Reviewed by COSEWIC April 1988. Species found to be not in jeopardy in Canada (not in any COSEWIC category).

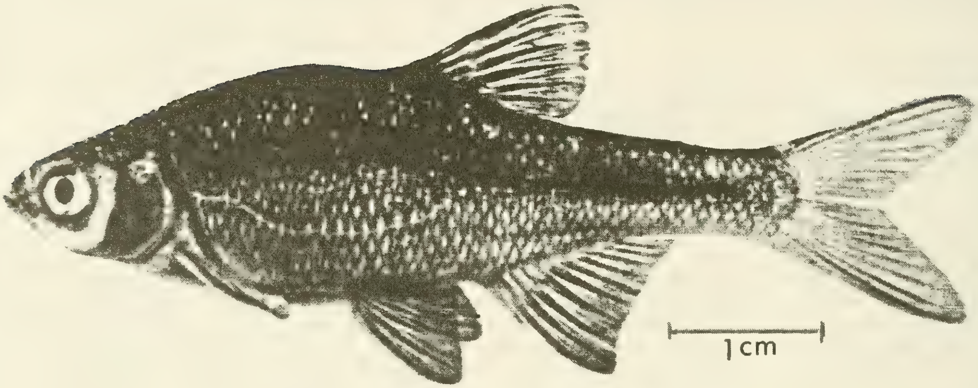

FIGURE 1. Redfin Shiner, *Notropis umbratilis*.

1985; Smith 1985). Problems identifying specimens of this species have been encountered frequently in the United States (Clay 1962; Snelson 1972, 1973; Snelson and Pflieger 1975; Cooper 1983; Robison 1985; Smith 1985). Redfin identification is simpler in Canada because the congeners causing this confusion do not occur in Ontario (Lee et al. 1980).

Distribution

The Redfin Shiner is endemic to North America: its distribution is restricted primarily to the east-central United States (Figure 2). The western margin of its range extends from eastern Texas and Louisana through eastern Oklahoma, Kansas and Iowa. To the north, it extends along southeastern Minnesota, southern Wisconsin and Michigan to western New York and northwestern Pennsylvania. Canadian populations thus occur on the extreme northern fringe of the species' distribution. To the east, the range is bounded by the western portions of West Virginia, Kentucky, Tennessee and Mississippi. Within these boundaries, its distribution is continuous. There is no evidence to support Hocutt and Wiley's (1986: 110) claim that the species is native to the St. Lawrence and Ottawa rivers and to Lake Champlain.

Other distribution details are outlined elsewhere (Jordon 1877; Forbes and Richardson 1920; Greene 1935; Trautman 1935; Eddy and Surber 1947; Langois 1954; Eddy 1957; Moore 1957; Hubbs and Lagler 1958; Clay 1962; Larimore and Smith 1963; Metcalf 1966; Cross 1967; Scott 1967; Smith-Vaniz 1968; Raney 1969; Pflieger 1971; Jenkins et al. 1972; Miller and Robison 1973; Scott and Crossman 1973; Douglas 1974; Eddy and Underhill 1974; Cross and Collins 1975; Pflieger 1975; Snelson and Pflieger 1975; Snelson 1980; Hubbs 1982; Becker 1983; Cooper 1983; Smith 1985; Etnier and Starnes *in preparation*).

The species is polytypic (Snelson and Pflieger 1975), the eastern subspecies being designated *Notropis umbratilis cyanocephalus* (Copeland *in* Jordan 1877), the western subspecies *Notropis umbratilis umbratilis* (Girard 1857). *Notropis*

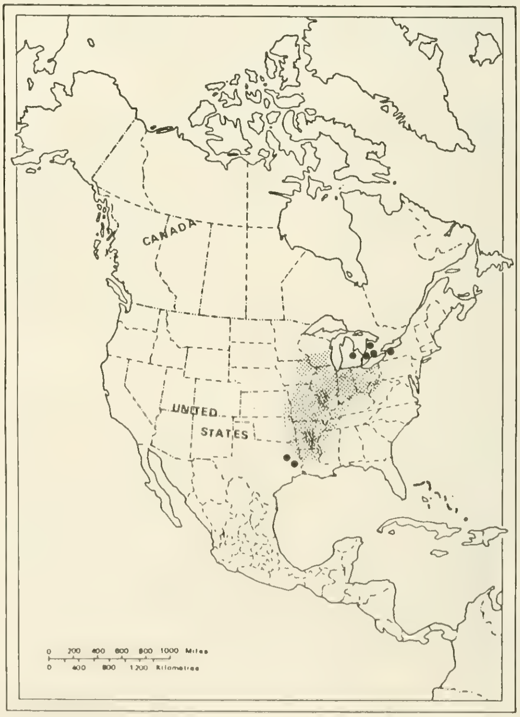

FIGURE 2. North American range of the Redfin Shiner (*adapted from* Snelson 1980). Ontario distribution as previously recognized.

umbratilis cyanocephalus ranges from Texas and Louisiana through eastern tributaries of the Mississippi River to southeastern Minnesota and east to western New York. *Notropis umbratilis umbratilis* occurs in eastern Oklahoma, Kansas, and western Missouri (Snelson 1980). Zones of intergradation occur in northeastern Missouri and in west-central Arkansas (Pflieger 1971; Snelson and Pflieger 1975; Snelson 1980; Becker 1983; Matthews and Heins 1984; Etnier and Starnes *in preparation*).

The Redfin Shiner was known previously in Canada from only six published locations. These were Ontario tributaries of southern Lake Huron, Lake St. Clair and Lake Erie (Hubbs and Brown 1929; Radforth 1944; Scott and Crossman 1973; Snelson 1980; Noltie and Smith 1988) and an isolated population from a Bruce Peninsula lake (Harvey 1981). As such, the redfin is the only member of the subgenus *Lythrurus* to have invaded the Great Lakes basin (Snelson 1972). The report by Evermann and Latimer (1910) and Hinks (1957) of the species' occurrence in Manitoba's Lake of the Woods was determined erroneous (Hubbs 1945; Keleher and Kooyman 1957). Eddy and Surber (1947), Eddy and Underhill (1974), and Becker (1983) report that populations do not occur in the Lake Superior drainage.

To update the Canadian distribution of the Redfin Shiner, three data bases containing capture records were examined: deposits of voucher-specimens from (1) the National Museum of Natural Science, (NMC), (2) the Royal Ontario Museum (ROM), and (3) records of the Ontario Ministry of Natural Resources (OMNR) stream survey collections. Catalogue sheets describing various NMC depositions were aquired directly. ROM records were accessed by cross reference with the OMNR's Fish Species Distribution Data System and were supplemented by further direct communication. Museum personnel verified most holdings at both museums. Known OMNR survey catches were summarized using the OMNR's Data System. The original species catch and identification records and their associated aquatic habitat inventory summaries were then obtained from individual OMNR district offices. Species identifications for preserved specimens from these catches had been verified by experienced personnel under contract to the OMNR's Fisheries Branch. Some collections have since been deposited at the ROM. Additional OMNR records known locally were also obtained.

Based on these records (Figure 3; *see also* Noltie 1987), the distribution of the Redfin Shiner in Ontario is evidently more widespread than previously understood. Virtually all the streams comprising the species' southwestern Ontario distribution drain directly into (1) southeastern Lake Huron or watersheds of its main rivers, the Ausable, Sauble and Saugeen, (2) eastern Lake St. Clair or its main tributaries, the Sydenham and Thames river systems, and (3) northeastern Lake Erie.

The northernmost capture location is Hepworth [= Mountain] Lake on the Bruce Peninsula (44°42′N, 81°03′W). The southernmost is from the Ruscom River, a Lake St. Clair tributary (42°11.3′N, 82°38.9′W). The most western record is from Bear Creek (42°58.6′N, 82°57.8′W), a tributary of the Sydenham River. The most easterly population occurs in Lake Ontario's Bowmanville Creek, east of Toronto (43°58′24″N, 78°43′48″W). This last site is separated by more than 150 km from remaining southwestern Ontario catch locations which otherwise occur only as far east as Lake Erie's Stoney Creek (42°50.9′N, 79°55.2′W).

No other redfin captures have been made in northshore tributaries between Lake Ontario's Bowmanville Creek and Lake Erie's Stoney Creek. These streams have been extensively sampled by the OMNR, and in the greater Toronto area (but not as far east as Bowmanville Creek) by R. J. Steedman (Department of Zoology, University of Toronto, Toronto, Ontario, personal communication). The voucher specimens for the Bowmanville Creek collection could not be located (D. E. McAllister, National Museum of Natural Sciences, Ottawa, personal communication). The occurrence of Redfin Shiners in Bowmanville Creek is not improbable, however, since several New York populations occur almost directly across Lake Ontario from it (Snelson 1980; Smith 1985), a distance of about 75 km.

Ontario Redfin Shiners have been captured primarily in the lakes Huron, St. Clair and Erie drainage basins, and these basins also contain existing populations in the United States. Lake Huron populations may thus derive from those in Michigan (Hubbs and Cooper 1936). Populations in Lake St. Clair tributaries are closest to those from western Ohio (Snelson 1980; Trautman 1981). Populations from tributaries draining into northeastern Lake Erie occur opposite those lining the Lake Erie south shore in eastern Ohio (Trautman 1981), western Pennsylvania (Cooper 1983) and New York (Greeley 1929). This pattern of occurrence and proximity to American populations suggests that Ontario populations may have arisen from several different sources.

The earliest catch record is from 1915 (ROM 08431; Noltie 1987). Populations from the Middle Thames River (NMC 85-0604; ROM 42130; Noltie 1987) have been isolated there by large dams on the Thames since late in the last century (Ecologistics

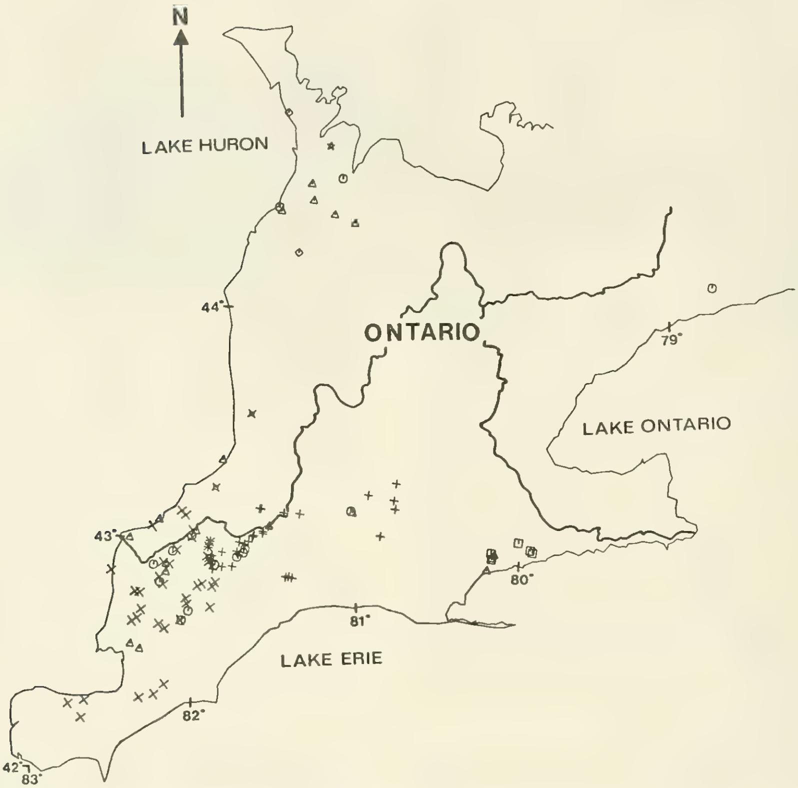

FIGURE 3. Map of the Canadian distribution of the Redfin Shiner, *Notropis umbratilis*. Heavy lines represent lake watershed boundaries. Locations correspond to collection records (*see* Noltie 1987) and are mapped by reporting organization as follows: Circle = National Museum of Natural Sciences; Triangle = Royal Ontario Museum; + = Alymer District, Ontario Ministry of Natural Resources (OMNR); X = Chatham District, OMNR; Diamond = Owen Sound District, OMNR; Square = Simcoe District, OMNR; Other = Wingham District, OMNR; Star = Harvey (1981).

Limited 1981; Noltie and Smith 1988). Hepworth [= Mountain] Lake on the Bruce Peninsula has no outflow and is fed only by a single, small creek (Harvey 1981), and its population of redfins has apparently been isolated for some time. These indications of longstanding occurrence suggest that the Redfin Shiner is a species native to Ontario. Its apparent novelty arises from a lack of sampling rather than recent invasion.

Protection

The Redfin Shiner is not currently the subject of any specific protection in Canada. Provisions of the federal Fisheries Act offer some general protection from potential habitat degradation, as do provincial and municipal statutes of this nature. Ontario fishing regulations govern the taking of minnows such as the redfin for bait purposes, forbid release of live specimens into waters other than those from which they were collected, and outline permissible methods of capture and possession limits. There is no closed season on the species. Ontario fishing regulations do prohibit daytime minnow capture in March, April and May. Because breeding redfins are conspicuously coloured and spawn during daylight hours later in the summer, these restrictions afford the species little protection.

Population Size and Trends

In some situations, numbers appear to be diminishing. Wisconsin populations are considered heavily depleted and continue to decline (Miller 1972) relative to their early distribution (Greene 1935). Wisconsin populations have thus been given "watch status" (Les 1979) and are at present of "special concern" (Johnson 1987). Part of this Wisconsin decimation is attributable to the use of toxicants in carp control programs (Becker 1983). In Michigan, redfins are considered rare (Hubbs and Cooper 1936). Redfins in both Pennsylvania and New York states are considered uncommon (Cooper 1983; Smith 1985).

In some areas of Ohio, decreased abundance has followed substantial increases in turbidity and especially silting of streams and riffle bottoms (Trautman 1981), the species having been declared "rare" in the Cleveland area (White et al. 1975). In New York, Smith (1985) suggests that the species is present in fewer localities than it was a few years ago. Abundance and size reduction downstream from a pollution source have been noted in Illinois (Thompson and Hunt 1930), even though the species was considered tolerant of pollution in small streams (Thompson and Hunt 1930; Larimore and Smith 1963). In Illinois, no indication of expansion in distribution or abundance has been detected over many years in parts of the state, despite man's influence tending to increase suitable habitat for the species (Smith 1968). Later work (Smith 1971) concludes the opposite, however.

In contrast, other southern populations appear less affected. Trautman (1981) states that no drastic changes in general distribution have been detected in Ohio during the past century. Increases in redfin relative abundance have occurred locally in Illinois and Ohio where turbidity and silting of stream bottoms has increased (Larimore and Smith 1963; Buth 1974; Trautman 1981). However, such increases may have resulted from the decline of other less tolerant species, leaving the redfin to expand into their vacated niches. Cases of more localized range extension have also been noted in Ohio, attributable to escapes of individuals used for bait (Trautman 1981).

Habitat

Redfin Shiners inhabit a broad range of habitat types. Snelson and Pflieger (1975) concluded that populations are almost invariably found in warm flowing waters. Strong currents and streams cooled by springs are largely avoided. Although the largest redfin populations occur in waters that are moderately clear, the streams they occupy vary greatly in turbidity. When inhabiting low-gradient streams, Redfins occupy pools within the main stream channel. In high-gradient streams, protected inlets or overflow pools away from the main flow are more often sought (*see also* Martin and Campbell 1953). In both situations, individuals are found in schools at or near the water's surface in deep, quiet pools. Stream size varies from small to medium, and in flow from slow in bayou areas to more rapid in high-gradient upland streams (Snelson 1980). In the north of the range, members of the eastern subspecies, *Notropis umbratilis cyanocephalus*, are reported to prefer sluggish, muddy streams in prairie regions (Hubbs and Lagler 1958). Hocutt and Wiley (1986) classify the species as an inhabitant of both lowland and glacial creeks and streams. Redfin habitat utilization by state in chronological order of its publication has been summarized elsewhere (Noltie 1987).

The habitat preference of Ontario *Notropis umbratilis cyanocephalus* remains little studied. Scott and Crossman (1973) report only that Ontario populations prefer the quiet waters of weedy ponds having abundant submergent and emergent vegetation. A lake population and its species complex is reported from the Bruce Peninsula (Harvey 1981).

Habitat data collected at 135 known capture locations were summarized. One hundred and twenty-nine sites (95.6%) were listed as streams, 3 (2.2%) as lakes, 2 (1.5%) as pools, and 1 (0.7%) was not reported. Thus, as elsewhere, Canadian populations are primarily fluviatile. Of the 129 stream sites, 70 gave complete reports of the presence or absence of pool and riffle zones at the capture location: 32 (45.7%) contained both, 28 (40%) contained some pool habitat but no riffle, 4 (5.7%) contained riffles but no pools, and 6 (8.6%) were evenly flowing stream sites containing neither. Thus, locations having at least some pool habitat predominate.

Stream widths at capture locations ranged from 0.3 to 53.5 m, averaging 5.9 m (S.E. = 0.9, n = 72). Most (75%) were less than 7 m across. Streams somewhat larger than this (modal width 12 to 24 m) were frequented in Wisconsin (Becker 1983), apparently the only other source of width data for northern catch sites, and elsewhere (Felley 1984). Ontario redfins were caught at sites averaging 38.0 cm (S.E. = 3.6, n = 74) in depth. Only three sample sites were deeper than 1 m.

Current flow at 10 sites was qualitatively assessed as slow in 50% of cases, and of medium speed in the remainder. Of 56 capture sites where current was measured, speeds from 0 to 7.7 m/sec were recorded, averaging 0.42 m/sec, (S.E. = 0.16). Currents were greater than 1 m/sec in only two cases, however. Discharge volumes ranged from 0 to 4.7 m^3/sec, averaging 0.46 m^3/sec (S.E. = 0.14, n = 55) comparable to findings elsewhere (Prophet 1957; Stegman 1958) but lower than in Illinois (Gerking 1949). Eighty-five per cent of sites had discharges of less than 1 m^3/sec. Qualitative assessment of site gradients were low ($< 10°$) in 76 of 77 cases, and medium (10° to 60°) in the remaining instance echoing findings for

Oklahoma and Illinois capture locations (Moore and Paden 1950; Larimore and Smith 1963).

Presence of submerged aquatic macrophytes was reported at 61 (69.3%) of 88 redfin capture sites assessed. Absence of vegetation was reported at the remainder. Sample site substrates were listed in 89 cases. These are summarized in Table 1 along with Wisconsin populations. That Ontario redfins are frequently captured where aquatic macrophytes occur and over a variety of substrate types is in conformity with many of the reports of the species' habitat utilization in southern populations (*see* Noltie 1987).

The total stream length reported for 69 of the capture sites averaged 60.3 km (S.E. = 5.4). Average stream gradient for the same sites was 1.11 m/km (S.E. = 0.10, n = 69), greater than the 0.6 to 0.8 m/km gradients of redfin streams in Kansas (Schelske 1957) and Illinois (Larimore and Smith 1963), but similar to that elsewhere in Illinois (Larimore et al. 1952). Mean recorded stream drainage area was 60 699 ha (S.E. = 8395, n = 67). Some streams produced captures from several locations along their lengths. These averages were calculated for all capture locations and are thus somewhat biased by repeated observations. To reduce this, a single datum was considered for each of the 27 water bodies comprising the data set. The unbiased averages are: stream length = 40.3 km, average stream gradient = 1.36 m/km, stream drainage area = 24 588 ha. No Ontario collections have been recorded from stream drainages greater than 163 583 ha in area. Thompson and Hunt (1930) and Larimore and Smith (1963) tested the relationship between redfin abundance and drainage basin area at point of collection along Illinois rivers but parallel tests cannot be made on the present data for Canadian populations.

Almost all the sampling dates for which site water temperatures were recorded occurred during the summer. The average of 20.5°C (S.E. = 0.6, n = 83) may thus represent a crude estimate of the species' thermal preference. However, captures over a broad range of temperatures (–1.1 to 31.0°C) suggest substantial thermal tolerance. The species' critical thermal maximum being 35.5°C (Mattheuse 1987). Captures at U.S. locations occurred over a similar temperature range (Canfield and Wiebe 1931; Moore and Paden 1950, Cross and Moore 1952; Cross 1954; Stegman 1958).

Dissolved oxygen at capture sites averaged 8.3 mg/l (S.E. = 0.3, n = 76). However, the range (2.4 to 17.8 mg/l) suggests that their tolerances (at least in the short term) are substantial, in contrast to Matthew's (1987) laboratory findings. Similar readings have been obtained at U.S. capture sites (Canfield and Wiebe 1931; Prophet 1957; Stegman 1958, 1959; Larimore and Smith 1963). pH values averaged 7.9 (S.E. = 0.1, n = 78), ranging from 6.2 to 9.5. Ninety-one per cent of captures were in more basic waters (pH $\geq$ 7.0), all of the captures in more acidic waters occurring in Brown and Bear creeks in the vicinity of Petrolia. Redfins were similarly found in basic waters (pH 7.0 to 8.6) in Nebraska (Canfield and Wiebe 1931), Oklahoma (Moore and Paden 1950; Cross and Moore 1952), Kansas (Prophet 1959), and in Illinois (Stegman 1958, 1959; Larimore and Smith 1963), Ohio (Shurrager 1932), and in an Ontario lake (Harvey 1981). This suggests that acid precipitation may pose some threat to the species.

Turbidities at capture sites, averaged 94 JTU (S.E. = 10, n = 75) and ranged from 2 to 451 JTUs; evidence of broad tolerance at siltation among Canadian populations. At U.S. catch sites, turbidities also vary across a wide range (10-538 ppm; Prophet 1957; Stegman 1958; Larimare and Smith 1957). The distribution of Canadian turbidity measurements was bimodal, 77% of cases

TABLE 1. Distribution of substrate types found at 89 Ontario Redfin Shiner capture locations. Percentages add to greater than 100 since multiple substrate types existed at individual locations. Ranks denote frequency of occurrence. Data from Becker (1983) for Wisconsin populations are presented for comparison.

	This Study			Becker (1983)	
Substrate Type	n	(%)	Rank	Rank	(%)
Rock	13	(14.6)	9	-	-
Boulder	18	(20.2)	8	4	(12)
Rubble/Stones	42	(47.2)	5	3	(24)
Gravel	56	(62.9)	2	2	(24)
Sand	51	(57.3)	4	5	(6)
Silt/Mud	63	(70.8)	1	1	(29)
Clay	52	(58.4)	3	-	-
Muck	27	(30.3)	7	-	-
Marl	0	(0.0)	10	-	-
Detritus	37	(41.6)	6	6	(6)

being clustered around a peak of 30 JTUs and the remainder (23%) around a peak of 210 JTUs. Similarly, of 14 qualitative turbidity assessments, 11 (79%) record "muddy" conditions and three (21%) "clear". A similar dichotomy of either clear or more turbid water preference is also exhibited in the literature records for southern populations (*see* Noltie 1987).

Alkalinity measurements at Canadian capture locations averaged 202 mg/l (S.E. = 8, n = 76), ranging from 45 to 470 mg/l. Eighty per cent occurred within the range of 125 to 275 mg/l. At sites in the United States, alkalinites were similarly variable, ranging from 53 to 760 ppm (Canfield and Wicke 1931; Prophet 1957; Larimore and Smith 1967). Measurements of total dissolved solids at Canadian sites averaged 438 mg/l (S.E. = 21, n = 69), ranging from 237 to 1265 mg/l. All but four recorded measurements were below 650 mg/l, however. Solids at sites in the U.S. measured between 370 and 850 ppm (Larimore and Smith 1963). Specific conductivity averaged 612 μS/cm (S.E. = 20, n = 75) when corrected to 25°C using a 2%/C° correction factor (Environment Canada 1979), and ranged from 279 to 1350 μS/cm.

The average number of species (including *Notropis umbratilis*) occurring at Canadian sites where redfins were captured and where complete species encounter lists were available was 11.1 (S.E. = 0.5, n = 96), ranging between 3 and 25. Species co-occurring with redfins at over 75% of the above sites included the Bluntnose Minnow (*Pimephales notatus*), White Sucker (*Catostomus commersoni*), and the Johnny Darter (*Etheostoma nigrum*) [Table 2]. Additional species occurring at 50% or more of the redfin sites included the Common Shiner (*Notropis cornutus*) and the Blackside Darter (*Percina maculata*). Of 104 stations simply assessing the presence of redfins, 46% also record the co-occurrence of at least one *Lepomis* species over whose nests redfins are known to spawn.

The species with which Redfin Shiners occur in Ontario are similar to those in Kansas, Illinois, Ohio and Wisconsin streams and a Wisconsin lake (Stegman 1958, 1959; Minckley 1959; McNaught 1963; Buth 1974; Hoke et al. 1979; Laskowski-Hoke et al. 1982; Becker 1983). The Canadian species suite to which they belong is also similar to that typical of dwellers in gravelly or sandy riffles and short river stretches in Illinois (Thompson and Hunt 1930) and to a suite occurring in six of Illinois' Champaign county drainages (Larimore and Smith 1963).

Fathead Minnows (*Pimephales promelas*) were a common species associate in Nebraska streams (Canfield and Wiebe 1931), as were Bluntnose Minnows in Kansas stream pools (Metcalf 1959). Green (*Lepomis cyanellus*), Longear (*Lepomis megalotis)* and Orangespotted Sunfish (*Lepomis humilis)* were also found in several of the redfin

TABLE 2. The 20 most frequently co-occurring species caught at the 96 Redfin Shiner capture locations in which complete speciles lists were reported. n = number of sites, % = proportion of the total.

Common Name	Scientific Name	n	%
Bluntnose Minnow	*Pimephales notatus*	77	80.2
Johnny Darter	*Etheostoma nigrum*	73	76.0
White Sucker	*Catostomus commersoni*	72	75.0
Common Shiner	*Notropis cornutus*	66	68.8
Blackside Darter	*Percina maculata*	52	54.2
Creek Chub	*Semotilus atromaculatus*	45	46.9
Rock Bass	*Ambloplites rupestris*	37	38.5
Spotfin Shiner	*Notropis spilopterus*	30	31.3
Fathead Minnow	*Pimephales promelas*	27	28.1
Northern Pike	*Esox lucius*	27	28.1
Green Sunfish	*Lepomis cyanellus*	26	27.1
Pumpkinseed Sunfish	*Lepomis gibbosus*	26	27.1
Greenside Darter	*Etheostoma blennoides*	25	26.0
Carp	*Cyprinus carpio*	24	25.0
Mimic Shiner	*Notropis volucellus*	23	24.0
Longear Sunfish	*Lepomis megalotis*	21	21.9
Black Bullhead	*Ictalurus melas*	19	19.8
Brook Stickleback	*Culea inconstans*	18	18.8
Least Darter	*Etheostoma micoperca*	18	18.8
Redhorse Sucker	*Moxostoma* sp.	14	14.6
Yellow Bullhead	*Ictalurus natalis*	14	14.6

streams Metcalf (1959) sampled. Bluntnose Minnows and Longear Sunfish were also common species associates in Mississippi (Mathews and Heins 1984), but other community similarities are few. Cooper (1983) states that redfins are found together with Golden Shiner (*Notemigonus cryoleucas*) and the Striped Shiner (*Notropis chrysocephalus*) in Pennsylvania populations sharing the Lake Erie basin, neither of which were common at redfin capture locations in Canada.

General Biology

Age and Growth: Redfin Shiners reach a maximum length of about 88 mm (Eddy and Underhill 1974; Pflieger 1975; Etnier and Starnes *in preparation*), but seldom exceed 64 mm TL (total length) in Ontario (Scott 1967; Scott and Crossman 1973). The largest specimen reported in Mississippi was 70 mm (Hildebrand *in* Cook 1959), 75 mm in Kansas and Illinois (Cross and Collins 1975; Smith 1979), 76 mm in Oklahoma (Miller and Robison 1973), 81 mm in Ohio (Trautman 1981) and 81 mm TL in New York (Smith 1985). Snelson and Pfleiger's (1975) extensive examination of various museum collections revealed a maximum length of 67 mm SL (standard length estimated 84 mm TL by Beckert 1963) for males and 62 mm SL (estimated 78 mm TL) for females.

Young-of-the-year are 18 to 51 mm long, yearlings 33 to 56 mm long in Ohio (Pflieger 1975; Trautman 1981). Becker (1983) notes that Wisconsin young-of-the-year reached 39 mm TL by September, and reports on the size distribution of an adult population in Wisconsin. Missouri redfins attain lengths of 28 mm by the end of the first summer's growth and 43 mm at the end of the second (Pflieger 1975). Both males and females are sexually mature at one year and typically live somewhat less than 1.5 years, with few individuals living past two years (Pflieger 1975; Becker 1983; Matthews and Heins 1984). Adult size is generally between 40 and 67 mm SL (Snelson 1980), 46-74 mm in Ohio (Trautman 1981). Females 32 mm SL or larger were sexually mature in Mississippi (Mathews and Heines 1984). Males grow significantly larger and faster than females (Pflieger 1975; Snelson and Pflieger 1975).

Some original catch records for Canadian populations (n = 28) list the minimum and maximum sizes (TL) of the specimens preserved in large collections, or the total lengths of all specimens in smaller ones. Samples from various times of the year were represented (Table 3). This permitted a gross assessment of size variation in Canadian redfins with season. Analysis of variance indicated that season had a significant effect on fish size ($F = 6.48$, $p < 0.005$). Mean total lengths increased from June to August (Table 3). In contrast, mean lengths from October through December decreased, presumably as young-of-the-year were recruited into the sampled populations. Evidence of bimodality in the length-frequency distributions (denoted by the double ranges listed in Table 3) further supports this contention. A similar growth pattern was found in Matthews and Heins' (1984) Mississippi population. Maximum reported size among Ontario collections was 67 mm TL. Data on sex ratios in these collections is not available.

TABLE 3. Variation in mean total lengths of Ontario Redfin Shiners with season. Specimens were preserved in formalin.

Month	Mean Total Length (mm) ($\bar{x}$ ± 1 S.E.)	N	Range
June	50.7 ± 2.6	15	35-66
July	54.1 ± 2.2	9	39-61
August	57.1 ± 1.4	13	48-67
October	42.8 ± 4.4	6	29-30 44-53
November	36.8 ± 6.4	5	22-31 46-57
December	32.5 ± 5.5	2	27 38

Reproduction: Relatively little is known of the breeding biology of the Redfin Shiner. The breeding season varies throughout the range, and the following reports are arranged by increasing latitude.

In Oklahoma, Miller and Robison (1973) record spawning in late spring and summer. In Mississippi, Hildebrand (*in* Cook 1959) collected mature specimens in late April and seemingly spawned-out individuals in early June. Cook (1959) found gravid females and tuberculated males in mid-May. Mathews and Heins (1984) report a late April to late August spawning season here, the ovaries of females beginning to mature in early April and all females being reproductive in June. In Tennessee, Etnier and Starnes (*in preparation*) report that the spawning season extends from late April through July and early August.

In Kansas, Metcalfe (1959) captured young-of-the-year from streams in July and August. Cross (1967) found that spawning here occurred mainly in June at water temperatures of 21°C or higher, although breeding extended from May through July (Cross 1967; Cross and Collins 1975). In Missouri, spawning occurs from mid-May to early August (Pflieger 1975). In Illinois, Forbes and Richardson (1920) found that females were ripe by early June, and males were tuberculated from mid-May to early August. Gonad examinations by

Stegman (1958, 1959) indicated that the spawning season in Illinois began in June and extended into July. In Ohio, Langois (1954) found specimens spawning in the latter part of June. Trautman (1981) records taking Ohio specimens in July that were mature.

In Minnesota, Eddy and Underhill (1974) found that females were gravid from late May to late June. In Wisconsin, Becker (1983) found that spawning extends from early June to mid-August, spent females and males not fully tuberculated being taken during the latter period. Becker (1976) indicates that Lake Michigan drainage basin specimens breed in July and August. In New York, Raney (1969) records that spawning occurs mostly in June and July, as does Greeley (1929). Here, as in Wisconsin, males also became less tuberculated in August and September. Thus, the onset of the spawning seasons appears to be progressively delayed in populations occurring further northwards, moving from late April to May then late May. Breeding season duration also appears to shortern farther north.

Concerning fecundity, the ripe eggs in a Wisconsin female numbered 525 (55 mm TL individual) (Becker 1985). These were 0.75 mm in diameter. Six hundred and forty-five ripening eggs occurred in another female of 53 mm TL, along with others yet to mature. That two groups of eggs at different stages of maturity populated the ovaries suggests that this species may spawn multiple clutches (*see* Heins and Rabito 1986). In Mississippi females, clutch sizes varied between 219 and 887 ova, were correlated with female size; and were also shown to be produced in several clutches per year (Matthews and Heins 1984). The eggs in Mississippi specimens averaged 0.81 mm in diameter and the ovaries comprised up to 37.8% of the somatic weight of females (Matthews and Heines 1984) Thus, seasonal reproductive effort is comparatively high, the species being relatively r-selected (Balon et al. 1977; Matthews and Heins 1984). The urogenital papilla of adult females enlarges and protrudes during warmer months (Snelson and Pflieger 1975) and aids external sexing throughout most of the year (Snelson 1972).

Scott and Crossman (1973) report that southern Ontario females were gravid and that males were brightly coloured in mid-August. Noltie and Smith (1988) found other Ontario redfins in mid-June ready to spawn, males of 6.1 cm average FL [Fork Length] (S.E. = 0.1; n = 6) being brightly coloured and tuberculated, 5.5 cm (S.E. = 0.2; n = 5) females being gravid with their eggs free-flowing. The weights of males averaged 3.39 g (S.E. = 0.21), their gonadosomatic indices [GSIs] 1.04% (S.E. = 0.11). Females were lower in average weight, 2.33 g (S.E. = 0.16), but their GSIs were higher at 19.32% (S.E. = 0.48). The ovaries of a ripe Wisconsin female were of a similar relative size, constituting 13% of the total body weight (Becker 1983).

Redfin Shiners are peculiar in that they typically spawn over the nests of Green Sunfish (Hunter and Wisby 1961; Hunter 1962; Hunter and Hasler 1965; Pflieger 1975; Becker 1983; Smith 1985). Other colonially-nesting centrarchid hosts include the Longear and Orange-spotted sunfish (Pflieger 1975; Snelson and Pflieger 1975; Smith 1979; Trautman 1981, Noltie and Smith 1988). During spawning, redfins in numbers of one to over 100 individuals gather over sunfish nesting colonies. Here, males defend small territories which are contested vigorously. Larger, more aggressive redfin males obtain territories just above sunfish nests. The territories of smaller males occur at the sunfish colony edges or above the territories of larger conspecifics (Pflieger 1975).

Males leave their territories at intervals to pursue receptive females. As the female approaches a particular territory, the male joins her in parallel. The female then releases her eggs. These are fertilized simultaneously by the male, accompanied by intense body undulations. Most activity takes place between 1000 and 1430 hours. Activity by the sunfish males and water-borne milt or ovarian fluids attract breeding aggregations, inducing the redfins to spawn (Hunter and Hasler 1965; Pflieger 1975). Thus, spawning may intensify during sunfish nest construction or during active spawning by the sunfish themselves (Pflieger 1975). Post-spawning, the sunfish males then guard the redfin eggs, making no effort to prevent their deposition, although occasionally some eggs may be eaten (Becker 1985). Young redfins and juvenile sunfish may also intrude into the nests and eat the eggs on occasion (Hunter and Hasler 1965; Becker 1983).

This spawning over the nests of centrarchids has been considered almost invariable (Pflieger 1975). It may have arisen through overlap in the spawning habitats both species prefer (Trautman 1981). In some seemingly anomalous situations, however, redfins have been observed spawning in aggregations over sand and gravel in sluggish riffles or pools with currents in the apparent absence of *Lepomis* hosts (Clay 1962; Raney 1969; Miller and Robison 1973; Scott and Crossman 1973; Becker 1976; Trautman 1981; Smith 1985). Hence the species' grouping among the phyto-lithophilous guild of non-guarding fishes (Balon 1975). Langois (1954) noted a further anomaly in Ohio, where specimens spawned in open areas of rushes on the margins of large pools in a river.

Given the preceeding evidence regarding Redfin Shiner nest parasitism the relationship between redfin occurrence in Canada and the presence of host *Lepomis* species (*L. cyanellus, L. humilis* and/or *L. megalotis*) was examined using the 95 capture records in which both redfin and sunfish numbers were noted. Although the problems of comparing fish numbers in such rudimentary and unstandardized samples as these is recognized, redfin numbers averaged 14.1 (S.E. = 5.1, n = 42) where sunfish hosts were captured, and 9.2 (S.E. = 2.4, n = 53) where sunfish host species were not. Scott and Crossman (1973) argue that a breeding association should be unlikely in Canadian waters. However, a possible spawning association between redfin and Longear Sunfish at a Middle Thames River capture location (NMC 85-0604, *see* Noltie 1976, Table 1) is discussed in Noltie and Smith (1988).

Diet: Although Cross and Collins (1975), Smith (1979), Cooper (1983), and Smith (1985) state that nothing is known of the redfin's feeding habits, some information does exist. Sibley (1929) found that its food was composed almost entirely of insects gathered from surface drift. Stegman (1958, 1959) found the diet of Illinois specimens to be composed mostly of terrestrial insects from March through June. Eddy and Underhill (1974) state that the diet is composed primarily of aquatic and terrestrial insects, but may include filamentous algae and bits of higher plants. Pflieger (1975), Whitaker (1982) and Felley and Felley (1987) also indicate it to be a surface feeder. Whitaker (1982) found its food to be primarily of terrestrial origin and composed mostly of ants and adult midges. Active feeding apparently tends to diminish in September (Whitaker 1982). Little feeding occurs in winter.

Parasites: Knowledge of redfin parasites is lacking. Neither Hoffman (1967) nor Margolis and Arthur (1979) provide listings for the species. Bangham and Hunter (1939) report no parasites from samples taken at the eastern end of Lake Erie, although 37.4% of all cyprinids of various species were infected to some degree. Hinson et al. (1976) found no metacercariae of the trematode *Crassiphiala bulboglossa* in the Illinois redfins they examined. However, Muzzall and Rabalais (1975) report finding *Acanthocephalus jacksoni* in redfins from Ohio. Glochidia from the freshwater clam *Anodonta grandis* infected redfins from Michigan and successfully produced juvenile clams (Trdan and Hoeh 1982). In Canada, a single record from the OMNR's Chatham District, Brown Creek, Station 04 (*see* Noltie 1987, Table 1), notes that redfins captured there bore black-spot disease, evidence of trematode infection.

Hybridization: Hybridization with the Rosefin Shiner (*Notropis ardens*) has been reported (Trautman 1981), the suggested result of overlap in the species' spawning habitat preferences. In contradiction, Snelson and Pflieger (1975) state that the habitat segregation between these species is sufficient to consider them allopatric. Clay (1962) also reports that the two species breed in different habitats where they co-occur, Smith (1971) states that redfins supplant rosefins, and Snelson (1972) does not consider them to be close relatives. Because Red Shiners (*Notropis lutrensis*) also spawn over sunfish nests, hybrids between these and the redfin sometimes occur (Pflieger 1975). The failure of intrafamilial hybridization tests with the redfin are documented by Hubbs (1970).

Evolution: *Notropis* is the most speciose of all North American cyprinid genera (Gold et al. 1979; Robison 1985). It is represented by well over 100 species (Miller 1965; Bailey and Robison 1978). Much of the radiation in *Notropis* has occurred in the last ten million years (Gold et al. 1979). The redfin's closest relative appears to be *Notropis bellus bellus* (Snelson 1972). Speciation occurred allopatrically, *N. umbratilis* remaining in the Mississippi Valley and the *N. bellus* precursor invading Gulf Coastal streams east of the Mississippi River (Snelson 1972). Chromosomes number 50 (2n) and are described by Gold et al. (1979). Estimates of genetic variability are provided by Avise (1977).

Limiting Factors

The major factor limiting or reducing numbers and distribution in this species appears to be spawning habitat degradation. When not spawning, redfins are typically rather tolerant of turbidity and silted substrates (Snelson and Pflieger 1975; Smith 1979; Trautman 1981). However, if increased turbidities cause the preferred spawning habitat to become silt-covered, it is abandoned in favour of swifter riffles (Trautman 1981) This results in decreased abundance (Trautman 1981).

Stream flow and volume fluctuations, along with siltation and high turbities, may also limit the redfin's distribution (Cross 1967; Snelson and Pflieger 1975). Pollution and siltation have been implicated in the redfin's generally reduced distribution in parts of Illinois (Smith 1979), despite their supposed tolerance to pollution (Thompson and Hunt 1930; Larimore and Smith 1963) and occurrence in some polluted areas (Gerking 1945). Where Redfins demonstrate an affinity for vegetation its lack may also limit their distribution (Harlan and Speaker 1956).

In contrast to this information, there are some indications that turbidity, amount of vegetation, and bottom type do not affect redfin distribution in

Indiana (Gerking 1945). Although Smith (1968) concluded that stream degradation had not altered the species' abundance and/or distribution in Illinois, later work (Buth 1974) found that increases had occurred.

Thus, it is uncertain how Ontario redfins will respond to reductions in water quality. Increased siltation and turbidity seem to benefit the species initially, but if continued also destroy redfin habitats. Redfins have been found to respond to stream degradation by moving to higher gradient areas or swifter riffles in some streams (Trautman 1981). However, in southwestern Ontario it is often these small headwater areas which have been most modified by field drainage and stream channelization. Dams on such major rivers as the Thames will also limit future upstream movements.

Another limiting factor may be the established fish fauna in southwestern Ontario streams. Known piscivores such as the Northern Pike (*Esox lucius*), Rock Bass (*Ambloplites rupestris*), Smallmouth Bass (*Micropterus dolomieui*) and Largemouth Bass (*Micropterus salmoides*) occurred at 28, 38, 7 and 5% of redfin capture sites, respectively (Table 2). If Canadian redfins are as dependent upon sunfish nest parasitism for breeding as those Pflieger (1975) discusses, then the distribution of sunfish hosts may also be an important limiting factor. Since Canadian populations are on the northern fringe of the species' distribution, water temperatures may also restrict further range expansion.

Special Significance of the Species

Of note is the spectacular colouration breeding males of *Notropis umbratilis cyanocephalus* develop, their red fins contrasting strikingly with their steel blue bodies. Forbes and Richardson (1920) describe them as "an exceedingly handsome species". Eddy and Surber (1947) state that "in life the northern redfin shiner is a perfect gem of a minnow, for both its colouration and its perfect form". Because of its tolerance of quiet waters, it has been suggested as a potential aquarium species (Scott and Crossman 1973) and has been considered an excellent local aquarium fish (Raney 1969; Becker 1983). Such use is probably restricted to members of the eastern subspecies, since the fins of *Notropis umbratilis cyanocephalus* are more melanistic during breeding (Cross 1967; Snelson and Pflieger 1975).

In Ontario, the species is considered to have no importance as a bait or forage fish because of its diminutive size and scarcity (Eddy 1957; Scott 1967; Scott and Crossman 1973). However, given that the species is used extensively for bait in Iowa (Harlan and Speaker 1956; Scott and Crossman 1973) and elsewhere when common (Cook 1959; Raney 1969), it has some economic potential.

Evaluation

The Redfin Shiner populations in Ontario are the northernmost in the species' range. Although not as rare as Scott and Crossman (1973) and Snelson (1980) indicate, the species does occur only in southern Ontario and only in limited numbers and at relatively few known locations. Populations are similarly scarce in other northern areas (Michigan, Wisconsin, Pennsylvania and New York). Despite instances in the United States where populations have declined, the species generally fares well in relation to settlement and may initially benefit from low-grade increases in turbidity and siltation. The species also seems somewhat pollution-tolerant.

Because the water quality of Great Lakes' tributaries has generally declined in recent years, it seems likely that present Canadian population levels will remain stable or may even increase. However, the small, low-gradient streams the species typically inhabits are especially susceptible to levels of habitat degradation which surpass the tolerance of the species. The species' preference for somewhat alkaline waters may also indicate a sensitivity to acid precipitation or spring pulses of pH depression. Although Canadian Redfin Shiners occur on the fringe of the species range and their numbers are generally low, they appear not to be threatened (Cook and Muir 1984), and the species does not fall into one of the COSEWIC categories in contrast to preliminary consideration (Campbell 1985, 1987).

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Status of the Enos Lake Stickleback Species Pair, *Gasterosteus* spp.*

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A sympatric pair of stickleback species (*Gasterosteus* spp.) occurs in Enos Lake on Vancouver Island. These species are reproductively isolated and are adapted to alternative trophic niches. One member of the pair (the "limnetic" species) is a pelagic plankton-feeder whereas the other member (the "benthic" species) is a littoral benthos-feeder. Although both species occur in large numbers, they are restricted to one small lake in an area of rapid urban development. The major short-term threat to this unique species pair is the introduction of other fish species. The major long-term threat is urban expansion. Perhaps, to ensure their survival, this species pair might be transplanted to some less developed area.

On trouve dans le lac Enos, sur l'île de Vancouver, deux espèces sympatriques d'épinoche (*Gasterosteus* spp.). Ces espèces sont isolées pour ce qui est de la reproduction et peuvent exploiter alternativement différentes niches trophiques. L'une est pélagique et se nourrit de plancton (espèce limnétique) tandis que la seconde vit sur les fonds littoraux et se nourrit de benthos (espèce benthique). Les populations des deux espèces sont assez élevées, mais sont restreintes à un petit lac d'une région qui s'est rapidement urbanisée. À court terme, l'introduction d'autres espèces de poisson est la principale menace qui pèse sur ces deux espèces uniques tandis qu'à long terme, le développement urbain remplira ce rôle. Afin d'assurer leur survie, peut-être, ces deux espèces d'épinoche devraient être transplantées dans une région moins développée.

Key Words: *Gasterosteus*, stickleback, British Columbia, Gasterostidae, Threespine Stickleback.

The Threespine Stickleback (*Gasterosteus aculeatus* Linnaeus) is a small (35-55 mm), laterally compressed fish with a slender caudal peduncle (Figure 1). The three well developed dorsal spines and the pair of pelvic spines are characteristic of the species. They are variable in colour from silvery green to black, the sides are usually paler and the belly silvery. During the breeding season adult males develop red on the belly and flanks; the females have pink tints on the throat and belly (Scott and Crossman 1973).

The Threespine Stickleback, is widely distributed along temperate coasts throughout the northern hemisphere. Within this vast geographic range the species occurs in both fresh and marine waters and is characterized by a bewildering array of ecological forms and morphologically distinctive geographic isolates. Ultimately, some of these forms and isolates probably will receive formal taxonomic recognition. At present, however, the taxonomy of *Gasterosteus* is in chaos (Miller and Hubbs 1969; Hagen and McPhail 1970) and neither the geographic boundaries nor the morphological limits of the nominate species (*Gasterosteus aculeatus*) are clear. Indeed, the only thing that is clear is that *Gasterosteus aculeatus*, as it is now recognized, is not a single species but a complex of species (McPhail and Lindsey 1970; Bell 1976).

In such a confused taxonomic situation, where dozens of prior names are available and where there is no holotype, it would be foolish to name new species without a complete revision of the genus. This does not, however, lessen our responsibility to protect unique populations, and in particular, to protect situations where there is compelling evidence for more than one species. Such a case is Enos Lake on Vancouver Island.

Recently, McPhail (1984) described two sympatric forms of *Gasterosteus* in this lake (Figure 1). Genetically, the two forms are discrete entities. They are also reproductively isolated (Ridgway and McPhail 1984) and are adapted to exploit alternate trophic niches (Bentzen and McPhail 1984). Thus, these sympatric forms fulfil all the requirements of biological species (Mayr 1963) and should be recognized as such. The fact that both these species fit the current description of *Gasterosteus aculeatus* in no way lessens their reality. Unfortunately, it does influence the choice of names to be used for these species since it is not clear which, if either, of the species is *Gasterosteus aculeatus*. At present, the least confusing option is

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*Threatened status assigned by COSEWIC April 1988.

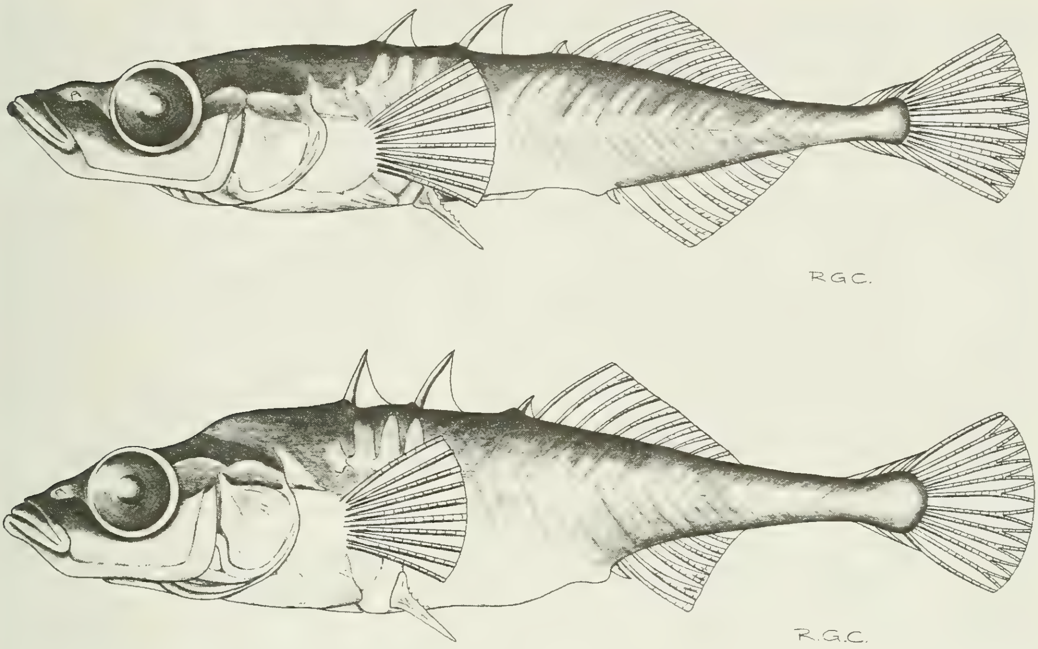

Figure 1. Enos Lake Sticklebacks. Top: limnetic male (44.3 mm standard length). Bottom: benthic male (49.3 mm standard length).

to refer to these animals simply as the Enos Lake species pair. Later, when their relationship to other divergent forms of *Gasterosteus* is better studied they can be given formal taxonomic names.

Distribution

As far as is known, this species pair is confined to Enos Lake (49° 17′N, 124° 09′W). The lake is near Nanoose Bay on the east coast of Vancouver Island (Figure 2).

Protection

There are no specific provisions to protect the Enos Lake species pair. Enos Lake, however, is a water supply for both Nanoose Bay and a Canadian Forces Base. Vehicle access to the lake is restricted.

Population Size and Trends

No quantitative estimates of population size have been attempted; however, both species are abundant and adult population sizes probably are in the order of 100 000 for each species. At least 1000 individuals of each species have been removed for study over the last 10 years with no obvious effect on population numbers. The populations appear to be stable, and certainly are not declining.

Habitat

Enos Lake is a small (17.6 hectare) coastal lake. It is 48 m above sea level and is connected to the sea by 1.5 km of intermittent stream (Enos Creek). The maximum depth is 11 m but most of the lake is less than 10 m deep (Figure 3). The water is lightly stained and in the summer dense beds of *Potamogeton* and *Utricularia* occupy the littoral zone. The lake stratifies during the summer and the hypolimnion becomes anoxic.

The only reproducing fish in the lake are the two sticklebacks. During dry periods, however, local residents occasionally rescue trout from adjacent streams and transplant them to Enos Lake. There is no permanent surface drainage into the lake and the outlet is dammed. Thus, the introduced trout do not reproduce.

General Biology

Both species in Enos Lake show the typical *Gasterosteus* life cycle and behaviour. There are, however, differences between the two species in their feeding and reproductive biology. One member of the pair is a pelagic plankton-feeder (the "limnetic" species) whereas the other member is a littoral benthos-feeder (the "benthic" species). They also differ in spatial distribution and seasonal habitats (Bentzen et al. 1984). During the summer the limnetic species occurs near the lake surface

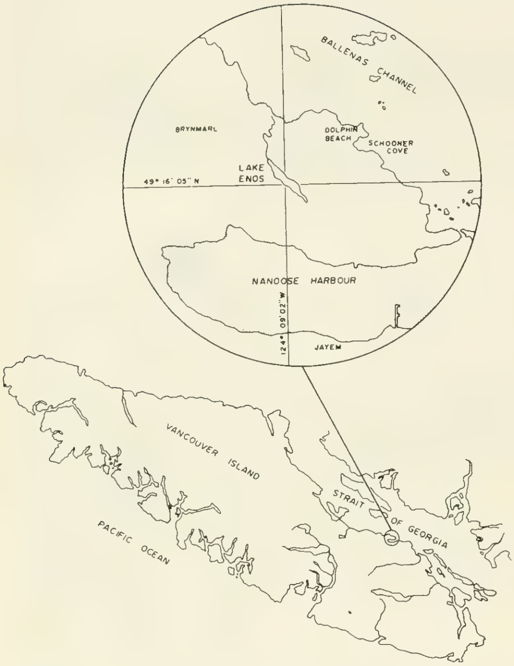

FIGURE 2. Map showing Vancouver Island and locations of Enos Lake (inset) and the Strait of Georgia region.

and moves to deeper water in the winter. In contrast, the benthic species occurs in the littoral zone during the summer and disperses over the entire lake bottom during the winter. The exceptions to this pattern are limnetic males. During May and June they nest in the littoral zone alongside breeding benthic males.

Within the limnetic species there is striking sexual dimorphism in body size and feeding behaviour. Mature limnetic females are smaller than males; they average 35 mm in standard length whereas the males average 45 mm. In addition, limnetic females are obligate and males are facultative planktivores (Bentzen and McPhail 1984). In the benthic species there are no obvious size or feeding differences between the sexes.

Limiting Factors

The populations of both species appear to be stable. Presumably, they are limited only by the carrying capacity of Enos Lake.

Special Significance of the Species

Understanding the mechanisms that produce biological diversity remains one of the fundamental goals of biology. One such mechanism is speciation: the process whereby one species divides into two or more new species. Although species formation has been a central issue in biology for over 100 years, remarkably little is known about this process. The reason for this ignorance is simple — it is extremely rare to find a species actually in the process of splitting into new species. Indeed, the process usually is envisaged as slow and requiring the subdivision of the species into separate geographic units.

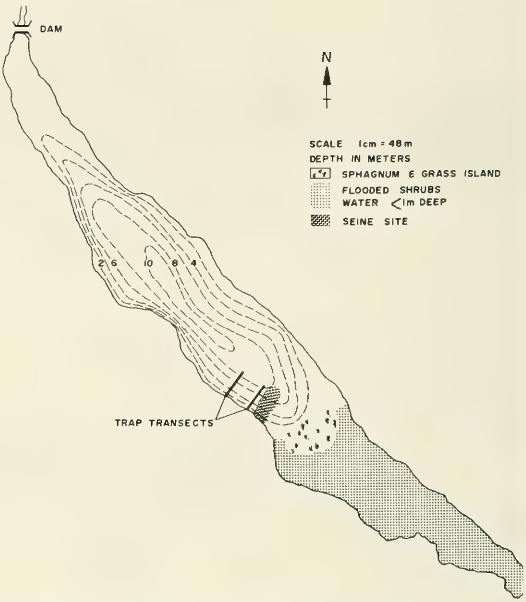

FIGURE 3. Bathythermic map of Lake Enos.

What is remarkable about the Enos Lake species pair is the rapidity with which the event has occurred (less than 12 500 years, *see* McPhail 1984) and the apparent lack of long-term geographic isolation. This is not to imply that geographic isolation did not occur in the Enos Lake speciation event, but only that it was of relatively short duration. Apparently, most of the morphological, ecological and behavioural differences that now occur between the limnetic and benthic sticklebacks in Enos Lake evolved within the lake. It is the speed of their divergence and this *in situ* evolution that make the Enos Lake species pair a unique scientific treasure.

Evaluation

The Enos Lake species pair is in no immediate danger. The populations appear stable and development around the lake is limited. The area between Nanaimo and Parksville, however, is growing rapidly and the demand for water from Enos Lake will certainly increase. Ultimately, the major threat to this species pair is the transplantation of exotic fish species, in particular, the Catfish

(*Ictalurus nebulosus*) and the Pumpkinseed (*Lepomis gibbosus*). These species are spreading gradually along the east coast of Vancouver Island. Their effect in large lakes appears minimal, but in small lakes (like Enos Lake) they can extirpate sticklebacks in two years.

In every small lake in the Nanaimo area where catfish have gained entry the local stickleback population has become extinct. The pattern is consistent: as the catfish population increases, stickleback recruitment decreases and eventually fails. The result is first an adult population with no young, followed by rapid extinction. The mechanism whereby catfish cause stickleback extinctions probably is nocturnal nest predation. In western North America there are no natural populations of large, nocturnal predatory fish. Consequently, *Gasterosteus* appears to lack any defence mechanisms appropriate for such a predator.

The effects of Pumpkinseed introductions are less spectacular than those of catfish introductions, but in at least one case (Diver Lake) a large stickleback population disappeared within two years of the first appearance of *Lepomis gibbosus* in the lake. The mechanisms of the Pumpkinseed — stickleback interaction are unknown but may involve territorial interactions between the males of the two species.

Unfortunately, it is difficult to prevent the introduction of catfish and Pumpkinseed. Both species are fished intensively by small boys who sometimes take them home alive in buckets. Eventually, these "pets" are released into ditches or ponds and another drainage system is colonized. Regulations are unlikely to be effective against this mode of dispersal.

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Status of White Whales, *Delphinapterus leucas*, in Ungava Bay and Eastern Hudson Bay*

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Reeves, Randall R., and Edward Mitchell. 1989. Status of White Whales, *Delphinapterus leucas*, in Ungava Bay and eastern Hudson Bay. Canadian Field-Naturalist 103(2): 220–239.

This paper evaluates the status of White Whales (*Delphinapterus leucas*) in two areas bordering northern Québec: Ungava Bay and eastern Hudson Bay. In both areas, White Whales have been hunted by Natives for subsistence. Also, intensive commercial net fisheries exploited White Whales in eastern Hudson Bay (mainly the Little Whale and Great Whale River estuaries) during the 1850s and 1860s and in southern Ungava Bay from the late 1860s to the turn of the century. The whales occupying southern Ungava Bay and eastern Hudson Bay in summer are taken to be separate management stocks. The Ungava Bay stock was centered historically in estuaries from Tasiujaq in the west to Kangirsualujjuaq in the east; the eastern Hudson Bay (Eastmain) stock, from Akulivik in the north to Great Whale River in the south. Whales from both of these stocks probably overwinter in Hudson Strait and Ungava Bay and perhaps near the mouth of Hudson Strait. Among many uncertainties regarding stock definitions and boundaries, it is unclear whether all, some or none of the whales found in summer in James Bay belong to the Eastmain stock. Recent aerial surveys have shown that the number of whales summering in southern Ungava Bay is only a few tens of individuals, compared with at least 800–1000 in the 1870s. Numbers estimated at more than 1500 are present during the summer in traditionally-occupied areas along the Eastmain, where there were at least 6600 animals in the 1850s. Both stocks continue to be hunted, although since 1986 community quotas have been set and hunting has been banned at the Marralik River of southern Ungava Bay. The Ungava Bay stock is clearly endangered, and any further harvesting will delay or prevent its recovery. The Eastmain stock may be able to sustain continued harvesting. However, there are at least four reasons for concern about its status: 1) even using optimistic assumptions to estimate past and current population size, the Eastmain stock appears to be about half its size in the mid-nineteenth century; 2) current catch quotas are high relative to estimates of sustainable yield, allowing little or no surplus production to ensure population increase (particularly if there is hunting loss which is not counted against the quota); 3) the Great Whale River, formerly a major summer congregating site of White Whales, appears no longer to be used by appreciable numbers of whales; and 4) proposed and ongoing hydroelectric projects and other environmental modifications could adversely affect White Whale habitat in this region. We therefore recommend that the Eastmain stock be classified as threatened.

Dans cet article, les auteurs évaluent la situation du béluga (*Delphinapterus leucas*) dans deux secteurs se trouvant en bordure du Nouveau-Québec, soit la baie d'Ungava et l'est de la baie d'Hudson. Dans les deux secteurs, les bélugas ont été chassées par les autochtones à des fins de subsistance. Il y eu également une pêche commerciale intensive des bélugas à l'aide des filets dans l'est de la baie d'Hudson (surtout dans les estuaires des Grande et Petite rivières de la Baleine) pendant les années 1850 et 1860 et dans le sud de la baie d'Ungava de la fin des années 1860 au début du siècle. Les baleines qui se trouvent dans le sud de la baie d'Ungava et dans l'est de la baie d'Hudson en été sont considérées provisoirement à des fins de gestion comme formant des stocks distincts. Dans le passé, le stock de la baie d'Ungava était concentré dans les estuaires de Tasiujaq à l'ouest à Kangirsualujjuaq à l'est; quant au stock de l'est de la baie d'Hudson (Eastmain), on le retrouvait de Akulivik au nord à la Grand rivière de la Baleine au sud. Les baleines de ces deux stocks passent probablement l'hiver dans le détroit d'Hudson, la baie d'Ungava et peut-être dans des régions situées près de l'entrée du détroit d'Hudson. Parmi les nombreuses incertitudes qui existent quant à la définition et à la limite des stocks, il n'est pas clair si toutes les baleines, certaines d'entre elles ou aucune, qu'on retrouve l'été dans la baie James, appartiennent au stock de l'Eastmain. Des relevés aériens récents ont révélé que le nombre de baleines qui passent l'été au sud de la baie d'Ungava est très faible, ne s'élevant qu'à quelques dizaines d'individus, en comparaison des 800 à 1000 individus au moins qu'il y avait dans les années 1870. Des quantités plus importantes, estimées à plus de 1500 individus, se trouvent l'été dans les secteurs habituellement fréquentés le long de l'Eastmain, où l'on comptait au moins 6000 têtes dans les années 1850. Les deux stocks continuent d'être chassés, même si, depuis 1986, on fixe des contingents pour les communautés et qu'une interdiction de chasser soit en vigueur dans le secteur de la rivière Marralik au sud de la baie d'Ungava. Le stock de la baie d'Ungava est de toute évidence en danger et toute exploitation ultérieure va avoir pour effet de retarder ou d'empêcher son rétablissement. Il se peut que le stock de l'Eastmain soit capable de soutenir un certain niveau d'exploitation prolongée. Cependant, il existe au moins quatre raisons pour lesquelles il faut se préoccuper de la situation: 1) même en étant optimiste dans l'évaluation de la taille actuelle et passée de la population, le stock de l'Eastmain semble être réduit à plus de la moitié environ de la population qui existait au

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*Reviewed by COSEWIC April 1988; an Endangered status was assigned to the Ungava Bay stock and a Threatened status to the Eastern Hudson Bay stock. This decision was to be reviewed in 1989.

milieu de dix-neuvième siècle; 2) les contingents actuels sont élevés par rapport aux estimations de rendement soutenu, permettant peu ou pas de production excédentaire pour qu'il y ait accroissement de la population (en particulier s'il y a une perte due à la chasse dont on ne tient pas compte dans le calcul du contingent); 3) la Grande rivière de la Baleine, qui constituait auparavant un endroit important de rassemblement des bélugas l'été ne semble plus utilisée par les baleines en nombre appréciable et 4) les projets d'hydroélectriques en cours et envisagés ainsi que d'autres projets entraînant des modifications de l'environnement pourraient amener une détérioration de l'habitat des bélugas dans cette région. Par conséquent, nous recommandons que le stock de l'Eastmain soit considéré comme "menacé".

Key Words: Beluga, White Whale, *Delphinapterus leucas*, Ungava Bay, Hudson Bay, conservation.

The White Whale or Beluga (*Delphinapterus leucas*) [see front cover] has a nearly circumpolar range in the Arctic and Subarctic, including the Canadian Western Arctic, Eastern Arctic and Hudson Bay. A review of the species' world distribution, as well as its life history and status, was given by the International Whaling Commission (1980). Their local seasonal abundance in many coastal areas has made White Whales important resources for the subsistence of northern peoples. Nowhere is this more evident than in northern Québec. Reliable access to White Whales appears to have been a major factor in determining ancient settlement patterns in at least southern and western Ungava Bay (Taylor 1975). White Whale hunting also was a traditional activity along much of the south coast of Hudson Strait (Graburn 1969; Augiak and Nowkawalk 1985; Reeves and Mitchell 1987a) and the east coast of Hudson Bay, called the "Eastmain" (Reeves and Mitchell 1987b). On the Eastmain, the prospects for commercial White Whale hunting spurred exploration and helped determine where trading posts would be established (Francis 1977; Francis and Morantz 1983).

With the closure of commercial White Whale fisheries in Canada by the early 1970s (Sergeant and Brodie 1975), continued exploitation has been limited to Native hunting for food (Hunt 1979; Fraker 1980; Kemper 1980; Brodie et al. 1981; Finley et al. 1982; Berkes and Freeman 1986; see Table 1) and to the capture of living whales for captive display or research (Brandson et al. 1979). The latter has taken place mainly in western Hudson Bay near Churchill (Reeves and Leatherwood 1984).

The St. Lawrence stock is considered endangered by the Committee on the Status of Endangered Wildlife in Canada [COSEWIC] (Pippard 1985) and the Beaufort Sea stock is "not in any COSEWIC category" (Finley et al. 1987). The purpose of this paper is to review available information and recommend a COSEWIC status for the Ungava Bay and Eastmain (eastern Hudson Bay) stocks of White Whales (Figure 1).

Distribution and Stock Identity

Ungava Bay stock

The summer distribution of this stock was centered historically in or near the estuaries of the Kangirsualujjuap Kuunga, Ungunniavik, Marralik, Kuujjuaq and Kuugaaluk rivers (Finley et al. 1982; Reeves and Mitchell 1987a) [Figure 2].

The recent or current summer distribution of this stock is centered from Tasiujaq to Kangirsualujjuaq (Anonymous 1987). At least as recently as the 1960s, large numbers of White Whales reportedly summered in the Kangirsuk area of western Ungava Bay as well (Currie 1968). The commercial fishery at Kuujjuaq from the 1830s to early 1900s operated mainly during July and August, and there is little published evidence of whales being present in southern Ungava Bay from October through May. Thus, the whereabouts of whales from the Ungava Bay stock from late fall through spring are not known with certainty. Major movements of White Whales have been observed in northwestern Ungava Bay, with whales passing southward off Cape Hopes Advance in September and October and northward in July (Currie 1968). During a shore watch at Cape Hopes Advance from 14 October to 4 December 1980, the first major movement of White Whales began on 1 November and the general pattern of movement was westward (Finley et al. 1982). Finley et al. (1982) found White Whales present in much of Ungava Bay and Hudson Strait during late March. It is reasonable to suppose that many of the Ungava Bay summering animals move offshore to avoid ice entrapment. It is also possible that some whales from this stock migrate in winter to the mouth of Hudson Strait, southern Davis Strait and the Labrador Sea.

Eastmain stock

Summer concentrations of White Whales formerly occurred at various sites along the east side of Hudson Bay, including Mosquito Bay near Akulivik, the Nastapoka River near Inukjuak and Umiujaq, Lac Guillaume-Delisle, Little Whale River and Great Whale River (Francis 1977; Finley et al. 1982; Francis and Morantz 1983; Reeves and Mitchell 1987b) [Figure 2]. White Whales have also been reported in much of James Bay and around the offshore islands (Belchers, Sleepers, Ottawas) [Smith and Hammill 1986]. As in Ungava Bay, whales are first noted soon after spring breakup, usually in June, and most have left the estuaries by the end of September. Some winter in James Bay (Jonkel 1969; Breton-Provencher 1980) and near the Belcher Islands (Freeman 1968), but most of the population

TABLE 1. Catches and estimated catches of White Whales by subsistence hunters in northern Québec, 1975–1986. Sources: Native Harvesting Research Committee (1976, 1979, 1982a, 1982b), Boulva (1981), Mitchell (1982), Goodman (1984), Anonymous (1985, 1987), Betteridge (1985), Mansfield (1987).

						Year							
Community	1973–74	1974–75	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Kuujjuarapik	28	24 or 26	60	55	51 or 53	63	75	32	45	46	35	40	10 or 11
Umiujaq[1]	—	—	—	—	—	—	—	—	—	—	—	—	3
Inukjuak	88	97 or 106	79	124	62 or 64	120	144	26	18	19	58	11	7
Povungnituk[2]	—	—	—	—	—	—	—	—	—	—	—	—	—
Akulivik	3	5 or 7	4	2	5 or 7	28	1	3	10	4	4	11	12
Ivujivik[3]	—	—	—	—	—	—	—	58	126	69	69	35	5
Salluit[4]	84	122 or 159	66	104	36	42	50	57	41	53	29	22	24
Kangiqsujuaq	150	162 or 174	98	118	62	74	37	14	21	22	26	32	22
Quaqtaq	26	31 or 36	55	85	39	30	65	28	25	38	46	32	21
Kangirsuk	37	43 or 48	44	79	10	4	4	14	9	12	3	7	9
Aupaluk	—	—	6	31	4	0	0	4	2	3	2	3	3
Tasiujaq	4	7 or 9	3	23	—	3	11	5	6	13	4	9	14
Kuujjuaq	41	53 or 64	102	30	13	34	31	30	29	12 or 14	5	2	10 or 12
Kangirsualujjuaq	10	19 or 27	20	15	10 or 11	37	14	26	12	3	5	3	5
Killiniq (Taqpangayuk)	0	8 or 15	9	16	—	—	—	—	—	—	—	8	1
Sanikiluaq	—	—	—	14	6	—	—	6	20(30?)	7	28	5	25
TOTAL	471	571-671	546	696	298-305	435	432	303	364–374	301–303	314	220	171–174

[1] New settlement established about 125 mi. north of Kuujjuarapik; incorporated in 1986.

[2] Povungnituk has not participated in recent harvest studies. During the 1950s the annual catch was estimated as 30 whales (Evans 1958). An exceptional catch of 103 was made one year in the 1960s (Finley et al. 1982).

[3] Though no harvest data were available for 1974-1980, Roy (1971) indicated annual catches varied from 10 to 300 White Whales, averaging 50–60 per year in 1962–1964.

[4] A portion of this settlement has refused to participate in harvest studies (Boulva 1981).

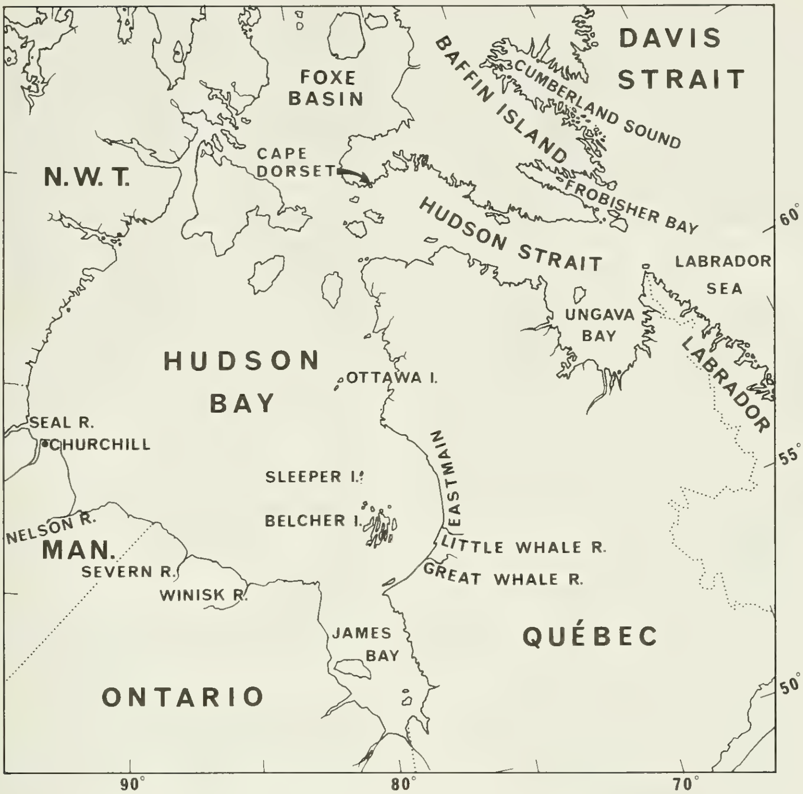

FIGURE 1. The Hudson Bay — Foxe Basin — Hudson Strait region.

summering on the east coast of Hudson Bay probably migrates northward in fall and southward in spring (Finley et al. 1982: 19–20).

Stock discreteness

Questions about the extent to which stocks of White Whales are discrete have been widely discussed and remain controversial. In the absence of obvious physical barriers, such as land or ice, to obstruct whale movements, other lines of evidence have been used to infer discreteness. Sergeant and Brodie (1969b) used "nonoverlapping differences in [body] size" as a way of identifying different White Whale populations. Mitchell and Reeves (1981) cited the Cumberland Sound population's long-term decline in abundance as evidence that it was not being replenished from other areas of summer concentration and therefore should be regarded as "a separate, fishable stock". In referring specifically to the Ungava Bay and Eastmain populations considered here, Finley et al. (1982: 20) regarded the "traditionality of their occupation of certain areas and the documented decline in numbers" as sufficient evidence for treating the two groups as different stocks for management purposes.

The Sub-committee on Small Cetaceans of the International Whaling Commission's (IWC's) Scientific Committee offered two broad approaches to the matter of White Whale stock discreteness, one viewing a wintering group as a single interbreeding population which disperses in spring, the other viewing various summering groups as separate stocks which winter in a common area (International Whaling Commission 1980: 117). The sub-committee stressed that direct evidence in support of either was lacking and that any assessment of stocks should consider both approaches. It was also recognized that the existence of "minor" wintering grounds, annual climatic variation (e.g., ice conditions) and other factors make available models of White Whale distribution and migrations (*see* International Whaling Commission 1980: 117–118, 120) oversimplified.

Reeves and Mitchell (1987a) stated four hypotheses regarding the stock relationships of White Whales in the Subarctic of eastern Canada:

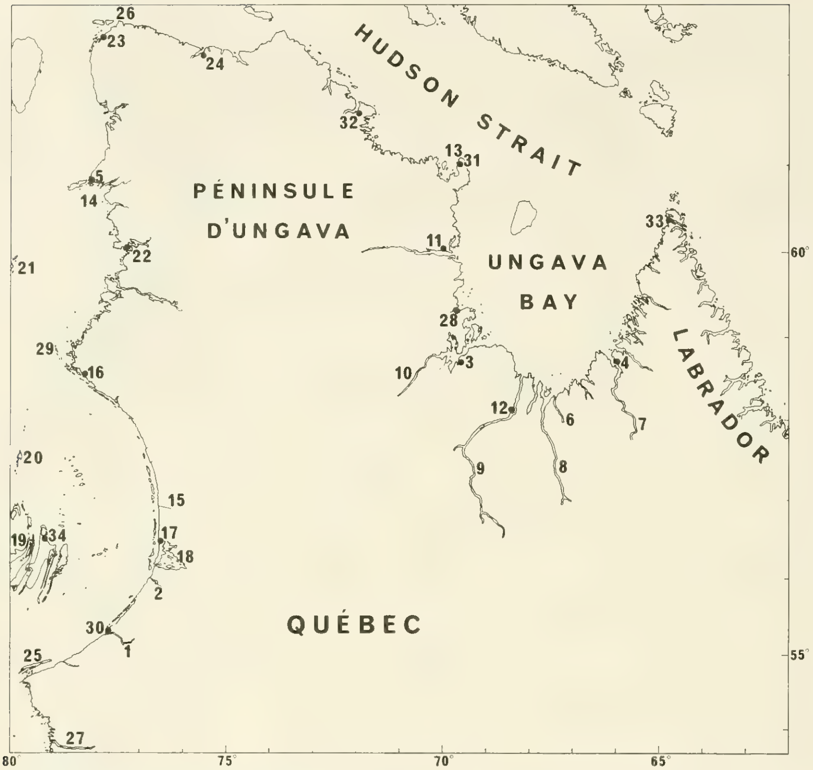

FIGURE 2. Map of northern Québec showing place names mentioned in the text; names are from Müller-Wille and Weber (1983) and Müller-Wille (1987).

1 — Great Whale River (Grand Rivière de la Baleine);
2 — Little Whale River (Petite Rivière de la Baleine);
3 — Tasiujaq (Leaf Bay; Baie aux Feuilles);
4 — Kangirsualujjuaq (George River, Port-Nouveau-Quebec);
5 — Akulivik (Cape Smith);
6 — Marralik (Mucalic) River;
7 — Kangirsualujjuap Kuunga (George) River (Rivière George);
8 -- Ungunniavik (Whale) River (Rivière à la Baleine);
9 — Kuujjuaq (Koksoak) River (Rivière Koksoak);
10 — Kuugaaluk (Leaf) River (Rivière aux Feuilles);
11 — Kangirsuk (Payne Bay, Bellin);
12 — Kuujjuaq (Fort Chimo);
13 — Cape Hopes Advance;
14 — Mosquito Bay;
15 — Nastapoka River;
16 — Inukjuak (Inoucdjouac, Port Harrison);
17 — Umiujaq;
18 — Lac Guillame-Delisle (Richmond Gulf);
19 — Belcher Islands;
20 — Sleeper Islands;
21 — Ottawa Islands;
22 — Povungnituk;
23 — Ivujivik (Wostenholme);
24 — Salluit (Sugluk, Saglouc);
25 — Long Island;
26 — Cape Wolstenholme;
27 — La Grande River (Fort George, La Grande Rivière);
28 — Aupaluk (Hopes Advance Bay);
29 — Elsie Island;
30 — Kuujjuarapik (Great Whale River, Poste-de-la-Baleine);
31 — Quaqtaq (Koartac);
32 — Kangiqsujuaq (Wakeham Bay, Maricourt);
33 — Killiniq (Port Burwell);
34 — Sanikiluaq

(1) the whales throughout Hudson and James bays, Foxe Basin, Hudson Strait and Ungava Bay and from Cumberland Sound to central Labrador belong to a single stock; (2) animals summering in Ungava Bay, eastern Hudson Bay, western Hudson Bay, Cumberland Sound and possibly James Bay and Frobisher Bay should be regarded as separate stocks; (3) there are only two stocks: one summering in Cumberland Sound and Frobisher Bay, the other in Ungava Bay, Hudson

Strait and Hudson Bay; (4) there are many different stocks, each recognized by its tendency to "home" in summer on a particular estuary or group of estuaries. In our evaluation of these hypotheses, we concluded that the second and fourth had "compelling merit for management purposes". We believe that a goal of management should be to maintain viable populations of a species throughout its range. This end is most likely served in the area considered here if, for management purposes, at least two stocks are recognized: the Ungava Bay stock and the Eastmain stock.

In their cooperative management plan for White Whales in northern Québec, the Department of Fisheries and Oceans, Québec Region, and Anguvigaq Wildlife Inc. (Anonymous 1987: annex 2) recognized four summer populations or stocks: Ungava, Southeastern Hudson Bay, Western Hudson Bay and Southeastern Baffin (Cumberland Sound). These distinctions are basically consistent with those made by Finley et al. (1982), Smith and Hammill (1986) and Reeves and Mitchell (1987a, 1987b). Both the Southeastern Hudson Bay and Western Hudson Bay populations are considered to include animals found [in summer] in James Bay.

It is possible to consider as distinct management units the populations of White Whales summering in different estuaries, particularly where the estuaries are separated by substantial distances and their occupation by whales is almost simultaneous. Visitation of the same estuaries in successive years by individual animals has been demonstrated by tagging (Sergeant and Brodie 1969a; Sergeant 1973) and sight-resight studies (Caron and Smith 1985; Smith and Hammill 1986). Thus, treatment of estuarine herds as separate "stocks" or population units may have meaning biologically as well as being useful for management. At the same time, it should be emphasized that there is too little evidence to conclude that these whales "home" on specific estuaries and remain there throughout the greater part of the summer season. Sergeant and Brodie's tagging studies, in which 1700 whales were tagged at the Seal River from 1967 to 1969, resulted in only two tag recoveries in the Seal River, in addition to "several" visual observations of tags on living whales during the tagging operations in 1968 and 1969 (Sergeant 1973: 1069). Of 18 White Whales individually identified at the Nastapoka River in 1983, eight were seen there one year later (Smith and Hammill 1986). However, the authors did not state whether these eight were resighted once or repetitively during a season. Unless the latter, which might demonstrate summer "residency," the whales may have "patrolled" along a wide stretch of coast, visiting a number of estuaries, and thus not "homed" in the above sense.

Richard (1987) has challenged the view that White Whale stocks can be defined on the basis of areas of summer concentration. His observations of large numbers of whales in northern, western and southern Hudson Bay during summer suggest that there is "a near continuous [coastwise] distribution in Hudson Bay" at that season. Particularly when considered alongside the distributions in James Bay and off the Eastmain coast to the Belcher Islands plotted by Smith and Hammill (1986), Richard's findings raise the possibility that there is some mixing of whales from different putative stocks in Hudson Bay, as well as James Bay, in spring, summer and fall. However, the lack of sightings between Little Whale River and James Bay (Smith and Hammill 1986) suggests a hiatus in present distribution along the southeast coast of Hudson Bay. Even if there should prove to be sufficient mixing to recognize the whales in Hudson Bay, Hudson Strait and Ungava Bay (possibly also those off southeastern Baffin Island and Labrador) as one biological population ("genetic stock" *sensu* Allen 1980:8; *see* Reeves and Mitchell 1987a), we consider the recognition of separate stocks, defined by their areas of summer concentration, to be a useful, conservative approach to management. Particularly if mature females and their calves are over-represented in the estuarine concentrations, a possibility for which there is some evidence (Caron and Smith 1985), and if mature females tend to "home" on particular estuaries more than other age- or sex-classes do, the multistock approach to management would help prevent local depletion or extirpation.

Protection

There is no international management of White Whales, even though some stocks occur in international waters or within the fisheries jurisdictions of several different states. The IWC's Sub-committee on Small Cetaceans has reviewed the status of White Whale stocks, but management of these stocks has not been considered a legitimate responsibility of the IWC. It seems likely that the Ungava Bay and Eastmain stocks remain year-round inside the Canadian 200-mile extended economic zone, making their conservation a national responsibility.

White Whales are listed on Appendix II of the Convention on International Trade in Endangered Species of Flora and Fauna. This means that, although there is no restriction on international trade in products, permits are required of the exporting country whenever such trade is conducted. There is a licensing system regulating live-captures in Canada. At present, no international trade in White Whale products is known, apart from the exchange of scientific specimens and the live-animal supply to zoos and oceanariums.

In Canada, Beluga Protection Regulations were issued under the Fisheries Act in 1949 and modified over the years (Table 2).

Negotiations among the Government of Québec, the Government of Canada, the Northern Québec Inuit Association, the Grand Council of the Cree (of Québec), the James Bay Development Corporation, the James Bay Energy Corporation and Hydro-Québec led to the signing of the James Bay and Northern Québec Agreement on 11 November 1975. Subsection 24.6.2 of this agreement states:

> The principle of priority of Native harvesting shall mean that in conformity with the principle of conservation and where game populations permit, the Native people shall be guaranteed levels of harvesting of all species in the Territory.

A James Bay and Northern Québec Native Harvesting Research Committee was formed to establish "present levels of harvesting" of each game species (including White Whales), by settlement, for 1973-75 (Phase I) and 1976-80 (Phase II) [Native Harvesting Research Committee 1979, 1982a, 1982b]. In addition to serving the needs of the Coordinating Committee on Hunting, Fishing and Trapping established under the 1975 Agreement, the studies of harvesting levels in northern Québec provided estimates of White Whale catches not previously available (Boulva 1981). The estimated harvest levels gave cause for concern about the possibility that stocks were being overexploited in northern Québec (International Whaling Commission 1980, 1981). Povungnituk, Ivujivik (until 1981) and a portion of Salluit did not participate in the harvesting studies (Native Harvesting Research Committee 1982b: 8).

Federal biologists recommended "safe harvest levels" (5 percent of minimum population estimates) for northern Québec White Whales in 1986 (Smith and Breton 1986; Smith and Hammill 1986). A 1984 agreement between Kuujjuaq and Kangirsualujjuaq banning White Whale hunting at the Marralik River was adopted by Anguvigaq at its Annual General Meeting in April 1986 (Weetaluktuk 1986a, 1986b). At the same meeting, quotas were assigned to all the White Whale hunting communities in northern Québec (Nalukturuk 1986).

The management plan adopted by the Department of Fisheries and Oceans in cooperation with Anguvigaq, in addition to reinforcing the provisions of the federal Beluga Protection Regulations, allocated a total northern Québec quota of 236 White Whales to be taken annually, as follows: 50 from eastern Hudson Bay (including James Bay), 161 from Hudson Strait and 25 from Ungava Bay (Anonymous 1987). The allowable catch was intended to include animals killed but not secured. The management plan included reference to the agreement for a White Whale sanctuary at the Marralik River. A new community fishing vessel at Kangirsualujjuaq was not to be used for hunting White Whales.

Population Size and Trends

Ungava Bay stock

The Ungava Bay stock has been exploited continuously for at least hundreds of years (Taylor 1975). A commercial fishery, involving driving and netting the whales, was established at Kuujjuaq in the 1860s and ended in the early 1900s (Reeves and Mitchell 1987a). Most evidence points to stock depletion as the cause of the fishery's decline, although it also appears that the whales became more difficult to catch by learning to avoid the nets. An attempt was made by the Hudson's Bay Company to revive its whale fishery at the Ungunniavik River during the late 1920s, but few whales were taken and the enterprise was abandoned. Since then, exploitation of the Ungava Bay stock has been limited to the Inuit subsistence hunt.

Finley et al. (1982) reasoned that the Ungava Bay stock could not have numbered less than about 1000 animals in 1880 to sustain the catches made during the 1880s, and our own study of the catch history confirmed this (Reeves and Mitchell 1987a). Sergeant and Brodie (1975) referred to a report of up to 1000 animals seen in Ungava Bay at one time, but they gave no details. A sighting of an estimated 400-500 whales at the Marralik River in August 1962 (Reeves and Mitchell 1987a), considered alongside the substantial catches reported for Kuujjuaq and Kangirsualujjuaq since 1974 (Table 1) [Kuujjuaq and Kangirsualujjuaq hunters hunt(ed) White Whales mainly at the Marralik River — Finley et al. 1982], confirms that at least some hundreds of White Whales survived into the 1960s and 1970s.

On the basis of aerial and land-based surveys in July 1980 Finley et al. (1982) concluded that the Marralik River was used by a maximum of 25 White Whales. Small groups were seen at the Kuugaaluk and Ungunniavik rivers and in False Bight north of the Kuugaaluk River. Intensive aerial surveys in the summer of 1985 revealed only two White Whales in Ungava Bay, and no meaningful population estimate could be made (Smith and Hammill 1986). Smith and Hammill (1986) also reported the results of aerial surveys conducted by Makivik Corporation in 1982: 11

whales seen in southern Ungava Bay in late July, 7–12 in late August and 6 in late September. The conclusion of Finley et al. (1982) that the Ungava Bay stock currently numbers "in the very low hundreds, at most" must be considered optimistic in view of the survey results published to date. We recognize the possibility that the animals sighted or killed in Ungava Bay during the past decade might represent "strays" from other stock areas. However, the simplest interpretation of these occurrences is that the Ungava Bay stock survives. We herein consider the population as extant but small, probably trending toward extirpation.

Eastmain stock

"Initial" population size was estimated to be at least 6600 on the Eastmain in 1854 (Reeves and Mitchell 1987b). This estimate refers only to the population(s) of whales entering the Little Whale and Great Whale rivers during summer (mainly June through August) and taken in the commercial net fishery. If the whales at other estuaries north of Little Whale River (e.g., the Nastapoka) were discrete stocks and usually did not move far enough south along the Eastmain to become involved in the commercial fishery at the Little Whale and Great Whale rivers, they would not have been taken into account in our minimum estimate of initial population size.

In the 1870s, when the commercial net fishery came to an end, Hudson's Bay Company officials continued to report large concentrations of White Whales at the Great Whale and Little Whale rivers. Native hunters continued to take White Whales after 1876, sometimes selling oil and hides to the Hudson's Bay Company (Reeves and Mitchell 1987b).

The first scientific census of White Whales on the Eastmain coast was made in 1978, when 300–400 animals were estimated to summer between Lac Guillaume-Delisle and Long Island (Breton-Provencher 1980). Finley et al. (1982) estimated a population of fewer than 350 whales in coastal waters between Cape Wolstenholme and Long Island in 1980, with an unknown number of additional animals distributed offshore and around the islands. The 1980 surveys did not include these offshore areas. Surveys by Makivik Corporation in mid-July 1982 resulted in a total of 339 whales sighted from the Nastapoka River to the Little Whale River (Smith and Hammill 1986).

Summer photographic surveys in 1985 resulted in a combined count of 474 whales at the Nastapoka River, Lac Guillaume-Delisle and Little Whale River (Smith and Hammill 1986). Thus, the coastal component of the population in 1985 was found to be about a third larger than estimated by Finley et al. (1982) in 1980. In addition, Smith and Hammill (1986) surveyed offshore to west of the Belcher Islands and estimated 650–1430 whales outside the coastal strip. Combining their offshore estimates with their inshore or coastal counts gave an estimate of 1124–1904 whales in eastern Hudson Bay. An additional 740–1970 whales were estimated in James Bay (Smith and Hammill 1986). The stock affinities of the whales in James Bay are unclear, but for management they have been considered at the same time part of the "Southeastern Hudson Bay population" [= Eastmain stock] and the "Western Hudson Bay population" (Anonymous 1987: annex 2).

The Eastmain stock appears to number several thousand, but there is no information on recent trends in its size.

Habitat

Ice cover is a major determinant of White Whale distribution (Fay 1974; Stirling 1980). Though able to survive in narrow leads and heavy pack ice (Finley and Renaud 1980), White Whales are susceptible to fatal ice entrapment (Freeman 1968; Mitchell and Reeves 1981). Their seasonal migrations and local, within-season movements in most areas seem related to changing ice conditions.

Their tendency to congregate in large numbers in estuaries helps define the summer distribution of White Whales. Whether this tendency is obligate or facultative is not yet clear, nor is the degree of "homing" on estuaries. The whales' persistence in returning to estuaries where they have been hunted suggests that such visitation fulfills a biological need, or perhaps that there is strong phylogenetic "inertia" for their doing so. Brodie (1971) ruled out breeding as a reason for the estuarine concentration in Cumberland Sound. Sergeant (1973) advanced the hypothesis that a thermal advantage might be involved, particularly where young calves are concerned.

The view expressed by such authors as Tomilin (1967) and Kleinenberg et al. (1969) that White Whales visit estuaries principally to feed is difficult to evaluate. Certainly some feeding occurs in or near estuaries (e.g., Doan and Douglas 1953; Breton-Provencher 1980; Sergeant 1973; Watts and Draper 1986), but in some estuaries the majority of whales sampled have had empty stomachs (Addison and Brodie 1973; Fraker *in* Davis et al. 1980: 14), indicating either that they had not fed recently or that the stomach contents had been regurgitated during the chase or capture. Seaman and Burns (1981) suggested that in the Bering Sea, where coastal water temperatures are mild in comparison to those farther north, movements and aggregation patterns relate principally to the availability of prey. There is a greater tendency to congregate in relatively warm estuaries regardless of prey density in the more northern regions. Applying this

TABLE 2. Development of Canada's Beluga Protection Regulations, under the Fisheries Act.

Year	Nature of Change	New Provisions	Citation
1949	Regulations established	Licence ($1.00 per year) required to hunt; Indians, Eskimos, "halfbreed" Indians or Eskimos, and members of Royal Canadian Mounted Police (RCMP) allowed to hunt without licence, for domestic use and dogfood; "meat" can be supplied to travellers; these regulations applied only to "the waters or the tidal tributaries of Hudson Bay, Hudson Strait, James Bay and Ungava Bay".	Order in Council P.C. 2707, 2 June (ordered).
1953	Amendment	Part of Churchill River made off-limits to commercial whaling.	P.C. 1953–578, Canada Gazette II, 87(9):349, Statutory Orders and Regulations (SOR)/53–140, 13 May (published).
1954	Substitution	None.	P.C. 1954–1725, Canada Gazette II, 88(23):1655, SOR/54–539, 8 December (published).
1955	Consolidation	None.	P.C. 1954–1725, Statutory Orders and Regulations, Consolidation, 1955, II (E-K), p. 1440.
1962	Substitution	Area of application extended to include all Canadian waters and territories north of 60°N; sport hunting permitted in 2 regions: Mackenzie Delta and Whale Cove; terms of sport hunting established, including methods of taking, quotas, disposal of products, licence fee structure.	P.C. 1962–678, Canada Gazette II, 96(10): 534–5, SOR/62–172, 23 May (published).
1965	Amendment	Churchill added to regions where sport hunting permitted; terms of sport hunting changed accordingly.	P.C. 1965–487, Canada Gazette II, 99(7): 419–20, SOR/65–114, 14 April (published).
1965	Amendment	Redefined Whale Cove Region as Whale Cove-Eskimo Point Region; removed annual sport-hunt quota from Whale Cove-Eskimo Point Region (quota now applied only to Mackenzie Delta).	P.C. 1965–1683, Canada Gazette II, 99(19):1578, SOR/65–433, 13 October (published).
1966	Substitution	"Halfbreed" designation changed to "person of mixed blood", at least ¼ Indian or Eskimo; in addition to natives and RCMP members, "residents" allowed to take belugas for domestic use or dogfood, "but not for sale or barter"; resident defined as a person who, "because he lives in an area remote from a normal food supply, is obliged to depend wholly or partly on belugas for food for himself, his family and his dogs"; terms stated for commercial hunting, including licensing and need to specify hunting area; Area Director, Department of Fisheries, Winnipeg, allowed to establish moratorium on hunting at any time "for conservation purposes".	P.C. 1966-950, Canada Gazette II, 100(11): 618–20, SOR/66–241, 3 June (published).

TABLE 2. *Concluded.*

Year	Nature of Change	New Provisions	Citation
1967	Amendment	Sport hunting provisions changed to allow a resident who holds a sport hunting licence to take belugas for sport "without a guide and using any boat, if he is accompanied by another resident who holds a beluga sport hunting licence"; residents also allowed to "sell all or any part of each beluga killed to a whale factory".	P.C. 1967–1202, Canada Gazette II, 101(12):1001–02, SOR/67–316, 26 June (published).
1978	Consolidation	None.	C.R.C., 1978, C.809, pp. 5057–59.
1979	Amendment	Area of application extended to include coast of Labrador, Gulf of St. Lawrence, St. Lawrence and Saguenay rivers and their tidal tributaries; full protection from hunting given to belugas in St. Lawrence system.	P.C. 1979–367, Canada Gazette II, SOR/DORS/79–169.
1979	Consolidation	None.	Departmental Manual of Acts and Regulations, DFO, Ottawa, Amendment List No. 7, 5 Dec.
1980	Substitution	General hunting requirements established, including: full protection of calves and of females accompanied by calves, use of rifles of greater than .22 calibre, and need to be "equipped with a boat and a harpoon with line and float attached"; residents (other than Indians and Inuit) required to have a licence to hunt; trade or barter of products allowed only within Northwest Territories and only by Indians and Inuit; prohibitions against "willful disturbance" of belugas and against failure to attempt to secure and fully utilize whales that have been struck; records of trade or barter of beluga products to be kept and provided on request to a fishery officer; schedule of quotas established by settlement hunting area; Pangnirtung assigned annual quota of 40 belugas.	P.C. 1980–1355, Canada Gazette II, 114(11):1944–46, SOR/80–376, 11 June (published).
1980	Amendment	12-month residency requirement for Indian or Inuk to hunt belugas without a licence removed.	P.C. 1980–2939, Canada Gazette II, 114(21):3445, SOR/80–835, 12 Nov. (published).

reasoning to Hudson Bay, Hudson Strait and Ungava Bay, we might expect the whales to be relatively opportunistic in their movements, following concentrations of food primarily. Hudson Bay and Ungava Bay have broad, shelving coastlines, with summer surface water temperatures of 5–8°C throughout most of Hudson Bay (Prinsenberg 1986).

Finley et al. (1982) and Finley (1982) repeated the belief of Native hunters that White Whales congregate in estuaries to molt (Figure 3), a hypothesis recently investigated by D. J. St. Aubin at the University of Guelph (*see* St. Aubin and Geraci 1989; St. Aubin et al. 1990).

Particularly in Cumberland Sound, local movements of White Whales are thought to be influenced by the movements of Killer Whales (*Orcinus orca*) [Kumlien 1879]. Killer Whales reportedly force White Whales close to shore, making it easier for the Inuit and Indians to hunt them (Doan and Douglas 1953; Higgins 1968; Sergeant and Brodie 1969b). There are relatively few records of Killer Whales in Hudson Strait, Ungava Bay and generally throughout Hudson Bay (Reeves and Mitchell 1988), so we would not necessarily expect predation to be a major factor in the distribution and movements of White Whales within these areas. However, the general absence of predators might contribute to the attractiveness of the region to White Whales.

Another interesting aspect of Hudson Strait, Ungava Bay and Hudson Bay as White Whale habitats is the absence of cetacean competitors there (e.g., Reeves and Mitchell 1987b). In some parts of the eastern Canadian Arctic Narwhals (*Monodon monoceros*) are seasonally sympatric with White Whales (e.g., Vibe 1950) and are potential competitors for Arctic Cod (*Boreogadus saida*) [Vibe 1950; Davis et al. 1980; Seaman and Burns 1981; Finley and Gibb 1982]. This potential for competition may be mediated to some degree by habitat partitioning in summer, the Narwhal preferring deep fiords and the White Whale shallow estuaries (Sergeant 1978), or by character divergence (Mitchell 1984). Narwhals are seen regularly but in low numbers in Cumberland Sound in summer (Brodie et al. 1981; Richard and Orr 1986). They are nearly absent from Ungava Bay and eastern Hudson Bay. Various groups of organisms other than cetaceans, such as seals and fish which are abundant in portions of Hudson Strait, Ungava Bay and Hudson Bay, may compete with White Whales for food resources.

In addition to the natural factors defining the White Whale's habitat, human-induced changes to the environment may influence carrying capacity (see below under Limiting Factors). We are unaware of any published study which quantifies and evaluates changes in the carrying capacity for White Whales, although such an exercise could be highly relevant for management. Also, an inventory of dams existing, under construction or planned would be useful, as would a compilation of tonnage and/or number of vessel passages in a given stock area.

General Biology

Feeding

White Whales have a varied diet, dominated by small schooling fish such as Capelin (*Mallotus villosus*), Smelt (*Osmerus* sp.), Herring (*Clupea* sp.) and Arctic Cod but including larger fish such as salmonids, and crustaceans, annelids and mollusks (e.g., Vladykov 1946; Kleinenberg et al. 1969; Seaman and Burns 1981). There are few published data on the prey of White Whales in eastern Hudson Bay, Hudson Strait and Ungava Bay. In eastern Hudson Bay, Breton-Provencher (1980) sampled the stomach contents of 21 White Whales. The majority of the stomachs were empty or contained only traces of food. She concluded that the whales in this region feed on the benthos to some extent, as they do in western Hudson Bay (Sergeant 1973). Two adult females taken at Cape Dorset in western Hudson Strait in September had Arctic Cod in their stomachs (Sergeant 1973). White Whales in western Hudson Bay are known to prey on Capelin, Sand Lance (*Ammodytes americanus*), Greenland Cod (*Gadus ogac*), Arctic Char (*Salvelinus alpinus*), squid and decapod crustaceans (Doan and Douglas 1953; Sergeant 1973; Watts and Draper 1986).

Vital parameters

Published estimates of vital parameters for western Hudson Bay and Cumberland Sound White Whales, combined, are given in Table 3 (*also see* Braham 1984 for a review) [Figure 4]. The gross annual reproductive rate for the St. Lawrence stock has been estimated as 0.083–0.09 (Sergeant 1986), which is lower than those of 0.09–0.12 estimated for arctic and Hudson Bay populations (Braham 1984). Density-dependent factors may have caused some differences in vital rates for the different populations since they have experienced differing intensities and durations of exploitation. However, it should be stressed that density-dependent effects have not been demonstrated for any life-history parameter of White Whales.

The difficulty of estimating natural mortality rates is an obstacle to understanding White Whale population dynamics (*see* Sergeant 1973; Ohsumi 1979; Ralls et al. 1980: 237). Most samples are thought to be biased either because of catching procedures or the segregated structure of the population in the area or season of sampling. It is unclear to us how biases in samples obtained from

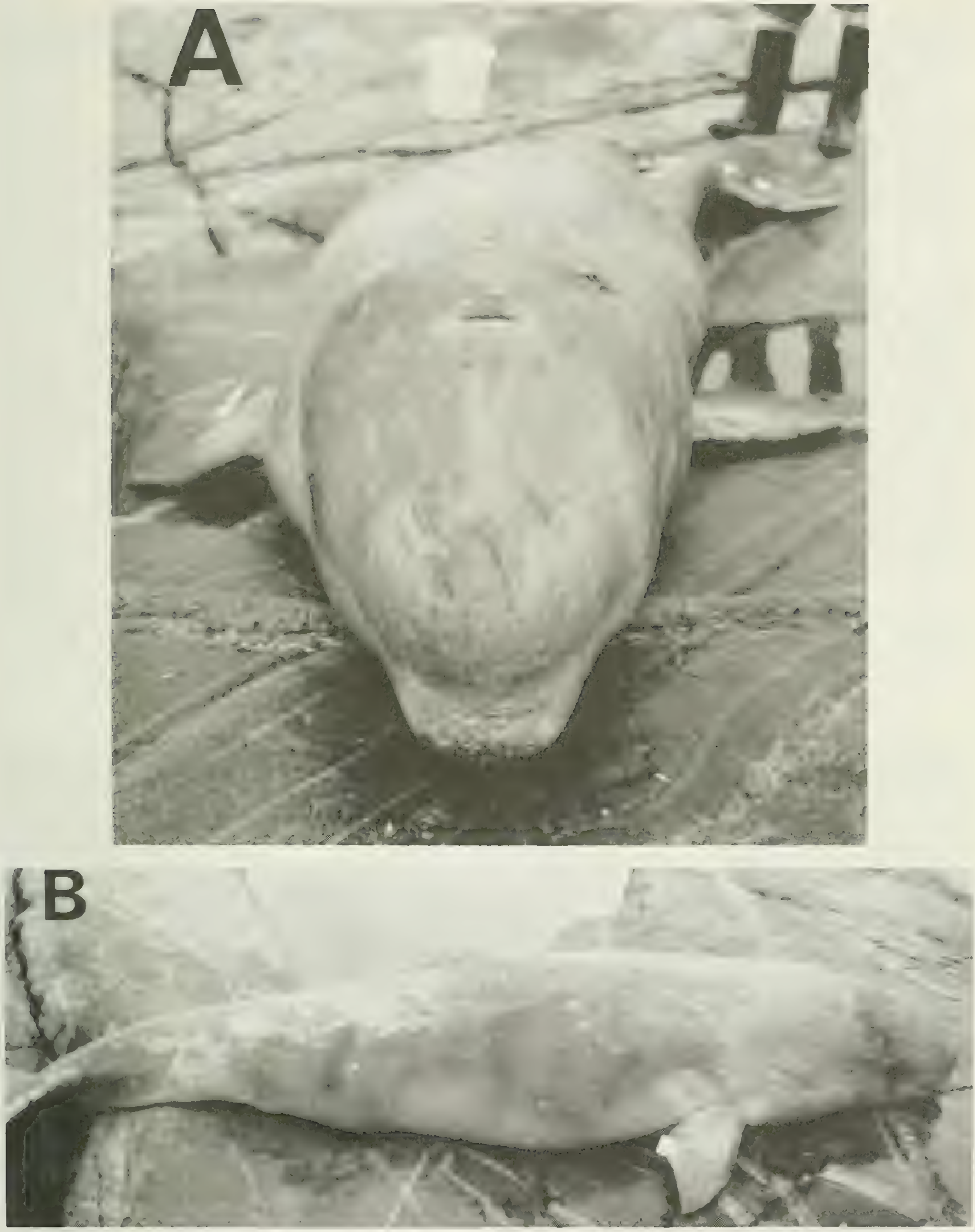

Figure 3. Anterior (A) and lateral (B) views of an immature female White Whale, 241 cm long, netted in the Marralik River, 8 August 1980. The dark vertical stripes evident in B are reminiscent of fetal folds, although judging by Sergeant's (1973) age-length curve for White Whales in western Hudson Bay the specimen would have been at least 5 GLGs (2+ years) of age. The skin shows evidence of molting, as mentioned by Finley (1982) and Finley et al. (1982). Photographs by K. J. Finley.

TABLE 3. Life-history parameters for western Hudson Bay and Cumberland Sound White Whales, from Brodie (1971) and Sergeant (1973). All estimates of age are based on the assumption of two dentinal GLGs and one mandibular GLG per year.

Mean age at sexual maturity, females	5 years
Mean age at sexual maturity, males	8–9 years
Peak time of conception	April–May
Peak time of births	Late June–early August
Gestation period	14–14.5 months
Sex ratio at birth	1:1
Length of lactation	1–2 years
Maximum longevity	20–30 years
Gross annual reproductive rate	11–14 percent
Calving interval	2–3 years
Mortality rates	No estimates

the subsistence fisheries can be eliminated or controlled.

Documented natural mortality factors include predation by Polar Bears (*Ursus maritimus*) [Heyland and Hay 1976; Smith 1985] and Killer Whales (Sleptsov 1952, *quoted in* Kleinenberg et al. 1969: 292; Reeves and Mitchell 1988) and ice entrapment (*see* Mitchell and Reeves 1981 for a summary of records).

Social behavior

White Whales are gregarious; groups of several hundreds or even thousands of animals are not unusual. The close association and coordinated movements of such aggregations have made it possible to conduct drive fisheries for this species (Lϕnϕ and Øynes 1961; Mitchell 1975; Kemper 1980; Mitchell and Reeves 1981; Reeves and Mitchell 1987a, 1987c).

The evident bias in his netted sample of whales led Brodie (1971) to suggest that in Clearwater Fiord at the head of Cumberland Sound, mothers and neonates favor shallow waters. In addition to what may be interpreted as fine-scale segregation, i.e. females and young distributed closer to shore within estuaries (Caron and Smith 1985), reports of herds consisting entirely or almost entirely of large white individuals indicate that adult males may form separate "bachelor herds" (Heyland 1974) during summer (Laurin 1982; (Lϕnϕ and Øynes 1961; Finley et al. 1982; Sergeant 1986).

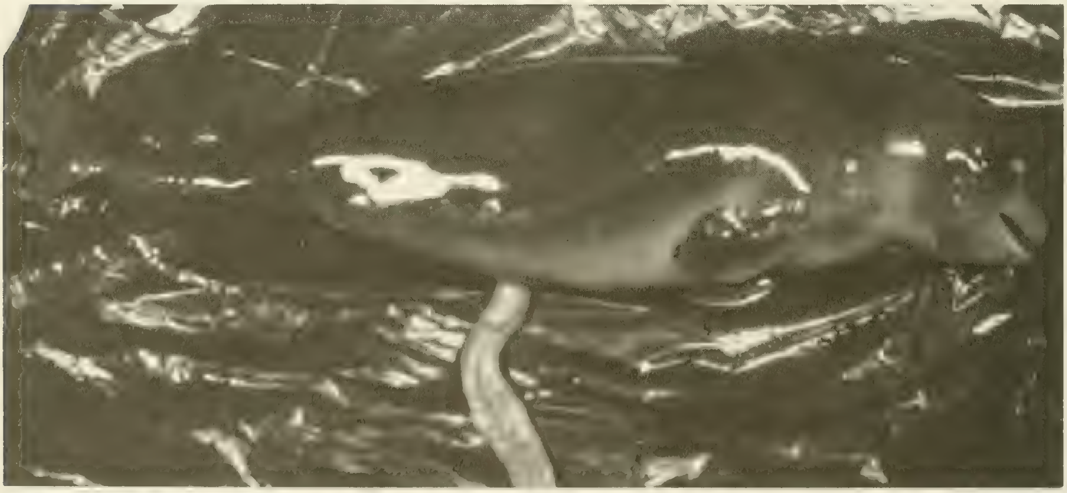

FIGURE 4. At 73 cm of length, this female fetus taken at Quaqtaq, Hudson Strait, 14 November 1980, fits close to Sergeant's (1973) fetal growth curve for White Whales in western Hudson Bay. It would have been conceived in spring 1980 and born in summer 1981. Pigmentation includes a lighter flank than dorsal cape, a dark external surface of the flipper confluent with the dorsal cape area but with an anteroventral extension similar to the flipper stripe of some delphinids (Mitchell 1970), the bottom half of a white "collar" ventrally and laterally sharply demarcating a dark "collar" extending from across the top of the head broadly around the eye and sweeping ventroanteriorly under the gullet. The entire beak, both upper and lower lips/jaws, is light. In the nature of the "eye patch", the shape of the dark collar running down and forward to the gullet and terminating in a point, the light "throat collar", the white snout and aspects of the flipper and axilla pigmentation, this fetus's pigmentation resembles that of some individuals of Cuvier's Beaked Whale, *Ziphius cavirostris*, and possibly other ziphiids. Photograph by K. J. Finley.

Special Significance of the Species

White Whales have been hunted commercially in many areas. They also have been hunted for sport (Sergeant and Brodie 1975) and live-captured for display and research (Brandson et al. 1979). In the St. Lawrence and Saguenay rivers particularly, and in the Churchill area of western Hudson Bay, White Whales have considerable value as aesthetic resources.

In Ungava Bay, Hudson Strait and eastern Hudson Bay, the principal value of White Whales to humans has been, and remains, that of a subsistence resource (e.g., Graburn 1969: 53). The archaeological record in Ungava Bay suggests that the Inuit have long depended upon White Whales (Taylor 1975). Early records of the Hudson's Bay Company leave no doubt that both the Inuit and the Cree (at least in eastern Hudson Bay and James Bay) hunted White Whales regularly and extensively before the arrival of Europeans to these shores (Davies 1963; Reeves and Mitchell 1987b). Several place names along the shore of northern Québec reflect the significance of White Whales in the lives of Native people. For example, Qarliit Tuvanga Bay (Baie Qarlituranga) (58°58′N, 65°44′W), just north of Kangirsualujjuaq, gets its Inuktitut name from being a place inhabited by White Whales (Müller-Wille and Weber 1983: 198). Qilalugarniavik Point (58°14′20″N, 68°18′30″W) in the Kuujjuaq River downstream from Kuujjuaq gets its name from its association with whaling. It is here that iron rings anchored the nets set on behalf of the Hudson's Bay Company to catch White Whales (Müller-Wille and Weber 1983: 202). The Ungunniavik River is so named because it was the place where [White] Whales were caught by beaching them (Müller-Wille and Weber 1983: 214).

While the muktuk from White Whales is still used consistently for human consumption (Figure 5), the meat and blubber (formerly used as dogfood) are not always retained by the hunters (Breton-Provencher 1980; Bauer 1981). The Inuit of eastern Hudson Bay are sensitive to the risks of consuming foods containing high concentrations of mercury, and since the meat of large White Whales in eastern Hudson Bay is generally above the government standard of 0.5 ppm, consumption of only the muktuk and not the meat is viewed as a sensible health precaution (Breton-Provencher 1980).

Limiting Factors

Natural factors limiting the abundance and distribution of White Whales in the core of their range probably include availability of food and

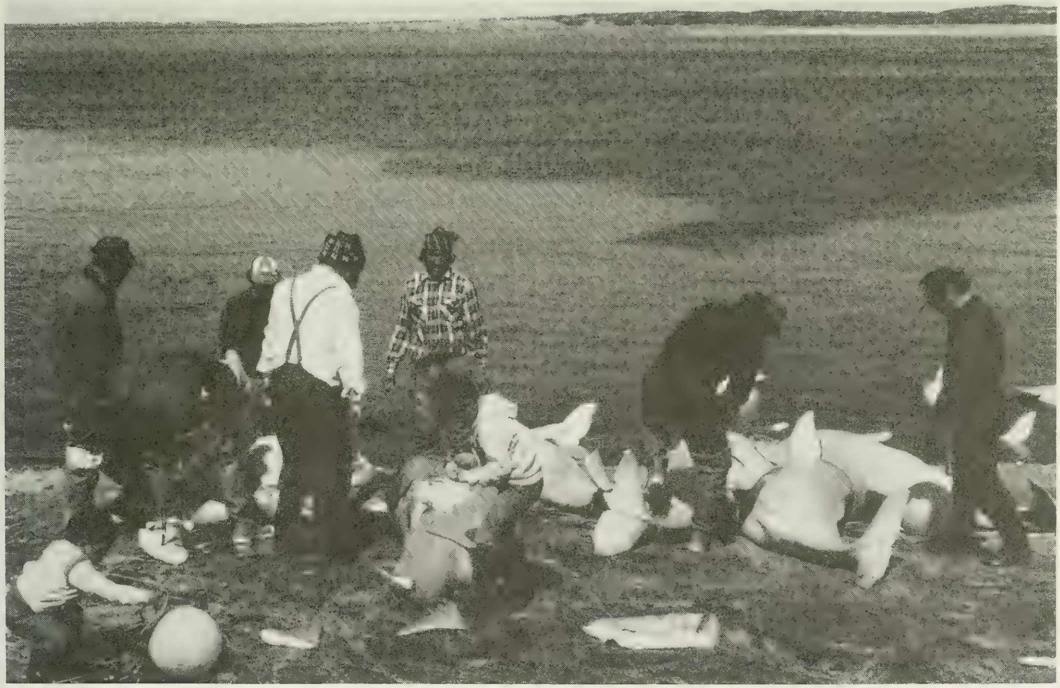

FIGURE 5. White Whales being flensed at the Nastapoka River, eastern Hudson Bay. Photograph by D. W. Doidge.

suitable summer habitat, ice conditions, predation by Killer Whales and Polar Bears and possibly interspecific competition. At the margins of their range, permanent or near-permanent ice cover (to the north) and interspecific competition may act to exclude White Whales. Predation by humans, possibly in combination with climatic change, appears to have reduced or eliminated White Whales along parts of the Labrador and West Greenland coasts (Vibe 1967; Reeves and Mitchell 1987a) and possibly in areas farther south along the North American coast (Sergeant 1986).

There is no reason to believe anything is more important than predation by humans as a factor limiting White Whale populations in Ungava Bay, Hudson Strait and Hudson Bay today. There are, however, three additional factors deserving close consideration.

Hydroelectric developments in northern Québec have included the damming of some rivers whose estuaries are or were used by White Whales in summer (Finley et al. 1982). Such manipulation of the environment certainly can have a major impact on estuarine ecology (e.g., Prinsenberg 1980; Berkes 1982; Messier et al. 1986), though it is not always clear whether the effects of a given development on a particular species will be favorable or unfavorable. In La Grande Rivière estuary, for example, there was an increase in the Cisco (*Coregonus artedii*) population after the completion of La Grande 2 (Messier et al. 1986), which could have worked to the advantage of an opportunistic predator such as the White Whale. On the other hand, changes in the physical and biological characteristics of estuaries could make them less suitable as congregating sites for White Whales.

In addition to development projects already completed or underway, there is reason to expect the scale of hydroelectric development in northern Québec to increase in the coming decades. Moreover, the Great Recycling and Northern Development (GRAND) Canal scheme proposed by Bourassa (1985) would involve the construction of a dike across James Bay, making it a freshwater lake supplying fresh water to the Great Lakes and other parts of southern Canada and the United States. Milko (1986) has discussed some of the environmental consequences of such a development. At a minimum, the movement of White Whales into and out of James Bay, an area where they occur in both summer and winter, would be precluded. The effects on White Whales of changes in the nutrient-transfer, salinity and ice-pack regimes of Hudson Bay, while more subtle, could be equally or even more severe.

Vessel traffic may have short-term effects on the movements and behavior of White Whales. The men who "fished" for White Whales in estuaries along the east coast of Hudson Bay during the nineteenth century frequently noted the whales' sensitivity to noise (Reeves and Mitchell 1987b). Quantitative studies in the Mackenzie Delta (*see* Norton Fraker and Fraker 1982; Norton Fraker 1983; Richardson et al. 1983) have failed to demonstrate any consistent, long-term impact of industrial activity on White Whale distribution, but in Lancaster Sound, Finley and Davis (1984) noted that White Whales gave alarm calls when an approaching ship was as far away as 84 km. The whales began a strong avoidance reaction when ships were still 35–50 km away. The White Whales consistently moved more rapidly away from disturbance, were displaced farther and returned to areas of disturbance more slowly than Narwhals. Considering that White Whales have a rich and complex acoustic repertoire (Schevill and Lawrence 1949; Fish and Mowbray 1962; Morgan 1979; Sjare and Smith 1986), it is reasonable to regard underwater noise pollution as a potential limiting factor. This noise pollution, and related disturbances, can be caused by industrial development (c.f., Stirling and Calvert 1983) or by maritime traffic generally.

A third possible limiting factor is low population size. The degree of isolation of the stocks considered here is not known with certainty. It has been suggested for stocks of mysticete whales that some critical population size may be reached at which recovery is biologically unlikely or impossible (Allen 1980; Mitchell and Breiwick 1983). If this were true for White Whales, it would most likely arise in connection with the Ungava Bay stock. It is possible that, even if all human-caused mortality were to cease, this stock is too small to generate sufficient recruitment to support any net recovery. The only hope for regeneration of the Ungava Bay stock may lie in dispersal from the other overwintering stocks in Hudson Strait.

DDT residues were found in the blubber (but not other tissues) of White Whales sampled in the Mackenzie Delta (Addison and Brodie 1973), and high levels of PCBs and other organochlorine compounds in various tissues of White Whales in the St. Lawrence River (Massé et al. 1986; Martineau et al. 1987). No studies have been published on contaminant levels in White Whales from Hudson Strait, Ungava Bay or eastern Hudson Bay, although Breton-Provencher (1980: table 9) gave total mercury concentrations in the muscle, liver and blubber of 22 whales sampled in southeastern Hudson Bay in the late 1970s (*also see* Wagemann and Muir 1984).

Evaluation

Ungava Bay stock

There is no doubt that this stock is endangered and that the safest course for its management would be to close the hunt for an indefinite period. The potential for continued use of White Whales as a subsistence resource in southern Ungava Bay, in both the short and long terms, can only be realized if there is a cooperative effort on the part of Inuit hunters, scientists and management officials to eliminate hunting pressure temporarily and monitor the stock's status. The existing management plan (Anonymous 1987) gave the "maximum sustainable harvesting level" for the Ungava Bay stock as zero; an (apparently) annual catch of 25 whales was allocated by Anguvigaq to Kangirsuk, Aupaluk, Tasiujaq, Kuujjuaq and Kangirsualujjuaq (5 whales each) for 1987 and 1988, to be taken from the Ungava Bay stock; and allowance was made for up to 43 to be taken from a "mixed stock" in Hudson Strait outside Ungava Bay. The allocated catch levels mentioned in the existing plan (Anonymous 1987) are too high to ensure the stock's recovery to initial abundance.

Eastmain stock

The conclusion of Finley et al. (1982) concerning this stock's conservation status may have been overly pessimistic in light of the subsequent findings of Smith and Hammill (1986). Although the latter authors demonstrated that there are more White Whales in eastern Hudson Bay than was supposed, both sets of surveys (Smith and Hammill's set including those by Makivik Corporation in 1982), in spite of intensive searches of the Great Whale River estuary, found no major summer concentrations of whales there. Breton-Provencher's (1980) survey in 1978 had revealed only about 50 whales (none of them calves) in this estuary. It must be concluded that the use of the Great Whale River by White Whales has declined markedly since the mid 1800s. Given that individual whales tend to return to the same estuary in successive years (Smith and Hammill 1986), recovery of the Great Whale River concentration to a level approaching "initial" or even the current carrying capacity of the habitat probably would be slow under the best of circumstances. Human activities in the vicinity of Kuujjuarapik, which include substantial aircraft and ship traffic as well as hunting (e.g., Breton-Provencher 1980: 29), may constitute a sufficient disturbance to help offset the effects of immigration by White Whales to this area.

A simple comparison of past levels of minimum abundance, ranging up to at least 6600 animals for the coastal waters from Great Whale River to Lac Guillaume-Delisle (Reeves and Mitchell 1987b), with present levels of 1124–1904 for the area between Elsie Island and Long Island, including waters offshore to and including the Belcher Islands (Smith and Hammill 1986), suggests that the stock is 17-29 percent of its "initial" (*ca* 1850) size. If the 740–1970 whales estimated by Smith and Hammill (1986) for James Bay are included, the present stock may be at 28–59 percent of initial size.

Smith and Breton (1986) recommended a "safe harvest level" of 56 animals per annum, or 5 percent of the lower bound of their population estimate for the Eastmain stock (1124 whales). Smith and Hammill (1986) made the same recommendation, citing Sergeant (1973, 1981) and Sergeant and Brodie (1975) for sustainable-yield levels of 0.05–0.10. More recent analyses indicate a maximum sustainable harvesting level of approximately 0.035 (Anonymous 1987: annex 2). Such an estimate is more in line with the published estimates of net recruitment rates for delphinids, which range from 1.7 to 3.2 percent (Perrin and Reilly 1984).

In view of its depleted state, continued exploitation and exposure to environmental modification (particularly river damming and diversion), we recommend that the Eastmain stock be classified as threatened.

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White-winged Scoter, *Melanitta fusca*, Populations and Nesting on Redberry Lake, Saskatchewan*

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We studied the nesting ecology of White-winged Scoters (*Melanitta fusca*) on Redberry Lake, Saskatchewan (52° 40′N, 107° 10′W) in the summers of 1977 to 1981. Most scoters arrived in early May about 30 days before the period of peak nest initiation. About 44% of the female scoters observed soon after first arrival were paired, but 96% were paired by 31 May. Peak numbers of pairs varied little among years and ranged from 389 to 423 scoter pairs during the third week of May each year. About 78% of the peak population left the lake by 31 July when broods were common. Nest success averaged 72.3% for all years and the mean date of hatch was 23 July. Nests with complete nest concealment had higher success rates than nests located in sparser cover ($P < 0.025$). Duckling mortality was highest during the first week after hatch, but numbers continued to decline during early and mid-August. Annual productivity never exceeded 0.5 duckling/breeding pair.

Key Words: White-winged Scoter, *Melanitta fusca*, breeding biology, nest site selection, populations, nesting ecology, sex ratios, Saskatchewan.

The breeding biology of White-winged Scoters, *Melanitta fusca*, is little studied in North America (Rawls 1949; Brown and Brown 1981). The size and composition of scoter populations vary during the breeding season, as in most ducks (Dzubin 1969; Trauger 1971), and current knowledge of these variations is inadequate to time censuses to estimate population size. Some aspects of the reproductive biology of White-winged Scoters seem enigmatic. Although nest success in White-winged Scoters and their European counterpart, Velvet Scoters (*Melanitta fusca*) is usually high, high brood mortality seems common in Velvet Scoter populations in Finland (Koskimies 1957a, b; Hildén 1964) and in North America (Brown and Brown 1981), resulting in low annual recruitment.

The large breeding population of White-winged Scoters on Redberry Lake, Saskatchewan, provided an excellent opportunity to study their reproductive biology. The objectives of this study were (1) to document the changes in numbers and composition of a White-winged Scoter population, (2) to determine the influence of nest site selection on nest success, and (3) to determine whether the productivity of White-winged Scoters on this lake was consistently low.

Study Area

Redberry Lake, about 65 km northwest of Saskatoon, covers about 6900 ha. The lake is a federal Migratory Bird Sanctuary, lies in the aspen parkland, and is surrounded by moderately rolling hills. The lake water is brackish (Rawson and Moore 1944) and the sandy or mucky shore and bottom lack emergent vegetation. Four islands of 38, 35, 4, and 2 ha are located in the western half of the lake. Red-shoot Gooseberry (*Ribes setosum*), rose (*Rosa* sp.), sow thistle (*Sonchus* sp.), Canada Thistle (*Cirsium arvense*), Fireweed (*Epilobium angustifolium*), dock (*Rumex* sp.), and grasses (Poaceae) including Common Reed (*Phragmites communis*) were the dominant vegetation; Quaking Aspen (*Populus tremuloides*) and willow (*Salix* sp.) grew on the higher grounds. During the past 20 years the water level of Redberry Lake dropped with a decline of 0.3 m between 1975 and 1980 measured at the summer low water level.

Lesser Scaups (*Aythya affinis*), Mallards (*Anas platyrhynchos*), Gadwalls (*Anas strepera*), Northern Pintails (*Anas acuta*), American White Pelicans (*Pelecanus erythrorhynchos*), Double-crested Cormorants (*Phalacrocorax auritus*), California Gulls (*Larus californicus*), and Ring-

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billed Gulls (*Larus delawarensis*) nested on the large islands, and Common Terns (*Sterna hirundo*) nested on the small islands. American Crows (*Corvus brachyrhynchos*) were common in the area and frequented the large islands, where two nests were found during the study.

Methods

We counted White-winged Scoters on Redberry Lake at 5 to 10 day intervals beginning in late May and ending in late July in 1977-1980. In 1980, counts were also made in early May. We systematically searched the entire lake by boat and recorded the landing points of birds that were accidentally flushed to prevent duplication of counts. Observations were classified as a pair, lone male, lone female, group (three to five birds), or flock (more than five birds) and we recorded the numbers and sex of all birds. Counts were made only when the lake was calm. We began about 0700 h and finished about 1400 h.

We searched the islands in Redberry Lake for nests twice between 25 June and 20 July each year. Most nest searching was conducted on the islands because only one nest was found during 60 h of searching mainland habitats. The dominant vegetation at each nest site and the percentage of concealment from above were recorded when we found each nest. Stage of incubation was determined by candling the eggs (Weller 1956). The egg-laying interval was estimated at 1.5 days per egg (Brown and Brown 1981), and we estimated date of initiation (i.e. date first egg was laid) by back-dating the nest. We only back-dated nests with clutches of 6 to 12 eggs.

We revisited nests about every 10 days and on the expected day of hatch; a nest was considered successful if a single egg hatched. Nest success was calculated using (1) the proportion of nests that hatched and (2) the modified Mayfield method (Miller and Johnson 1978). Females were captured with hand nets as they flushed from the nest; about 90% of all incubating females in known nests were captured each year. Females were banded with standard U.S. Fish and Wildlife Service leg bands and marked with a nasal saddle (Sugden and Poston 1968) bearing an alphanumeric code. We revisited the nests at hatching, captured the ducklings and marked them with web tags (Grice and Rogers 1965).

Counts of all ducklings on Redberry Lake were made four times each year. We made these counts when the weather permitted (i.e. lake was calm) and in the same manner as pair counts. We believe these counts were accurate because broods were highly visible (the lake lacked emergent cover) and scoter ducklings were never present on adjoining wetlands. In 1979, we captured ducklings at night using standard "night-lighting" techniques to mark additional ducklings and estimate the proportion of all ducklings that we had captured previously at nests.

Two indices of productivity were calculated based upon the number of ducklings observed in the last brood census divided by: (1) the average number of pairs on the lake between 1 and 20 June, and (2) the number of nests found on the islands. Habitat use was evaluated using chi-square tests (categorical data). Differences among years in nesting chronology and clutch size were tested using an ANOVA.

Results

Changes in Numbers and Composition. The earliest scoters arrived before studies began each year, but in 1980 counts were made soon after the scoters' first arrival and only 18 pairs were present on 9 May. In 1980, the main influx of birds occurred between 14 and 22 May (Table 1), with 78% of the peak population present by the later date. We never observed yearlings on the lake. Between 9 and 22 May, courtship was common in

TABLE 1. Mean numbers of White-winged Scoters observed in different social categories on Redberry Lake, Saskatchewan, 1977-1980. Values for 8 to 23 May are from 1980 only.

Interval	Pairs	Lone Male	Lone Female	Groups Female	Groups Male	Flocks Female	Flocks Male
8-15 May	68	42	0	23	48	8	32
16-23 May	331	111	3	32	7	6	60
24-31 May	396	144	4	37	102	22	57
1-8 June	406	123	1	36	55	15	46
9-16 June	420	144	2	14	54	11	48
17-24 June	337	118	14	25	74	26	137
25 June-2 July	207	99	32	35	82	44	210
3-10 July	42	47	34	69	37	89	109
11-18 July	8	19	78	106	16	117	32
19-26 July	1	6	83	82	7	81	17

groups of scoters with females. The proportion of females that were paired increased in May from 44% on 9 May (N = 41 females) to 86% on 14 May (N = 139), and 96% by 31 May (N = 139). The mean number of scoter pairs on Redberry Lake between 1 and 20 June was relatively stable among years of the study (1977—396; 1978—389; 1979—419; 1980—423) and followed a similar seasonal trend each year (Figure 1). Sex ratios (58-65% male before egg-laying began) were similar to those reported on Redberry Lake and Jessie Lake, Alberta, in 1976 (Brown and Brown 1981).

Numbers of pairs declined rapidly after mid-June, as females began incubation (Table 1). The small mid-June decline in total numbers resulted from females beginning incubation and not being counted. After 17 June, the number and percentage of birds in groups and flocks increased as some males and females ended reproductive attempts and joined groups or flocks. Counts of pairs should be made between 1 and 16 June; this is 7 to 14 days before most females began incubation. Birds in aggregations soon left the lake, presumably to molt elsewhere. Males departed earlier and in greater numbers than females. The departure of scoters from the lake caused a decline in total numbers after 24 June (Table 1). At the end of July, only 24% of the peak adult population (1159 birds) remained and 92% of these were females (Table 1).

Nest Sites and Nest Success. Although we counted about 400 scoter pairs on Redberry Lake each year, we found only 89 to 132 nests on the islands. Many females must have nested on the mainland or not nested at all. Of the nests located in the most frequently used cover types of Redshoot Gooseberry and Common Reed (Table 2), 90% were completely concealed. In contrast, 71% of the nests in other habitats were partially visible from above. Nests in habitats that provided complete or at least 80% cover had significantly greater rates of success ($P < 0.025$) than nests in sparser cover ($\chi^2 = 8.96$, 2 d.f.) (Table 3). Nest success averaged 73.2% for all nests in the study (Table 3). Nest success, using the modified Mayfield method (Miller and Johnson 1978), was calculated to be 68.4% (longevity for nests that did not hatch was estimated as 50% of the exposure period).

Nesting Chronology and Clutch Size. Clutch size was negatively correlated with the date of nest initiation ($R = -0.52$, $P < 0.0001$) and date of hatch ($R = -0.28$, $P < 0.001$). Dates of nest initiation and hatch were consistent among years (Table 4). The laying and hatching dates of 78 females captured in two or more years showed no pattern of change in nesting chronology related with increasing age, but this analysis did not compare known first nest attempts with later nesting attempts. Koskimies (1957a) made the same conclusion working with a similar data set. White-winged Scoters nested late in the summer, with more than 75% of all nests initiated between 8 and 22 June. Most nests hatched between 16 and 28 July. Mean clutch size and number of eggs hatched in successful nests did not vary ($P > 0.05$) among years (Table 4).

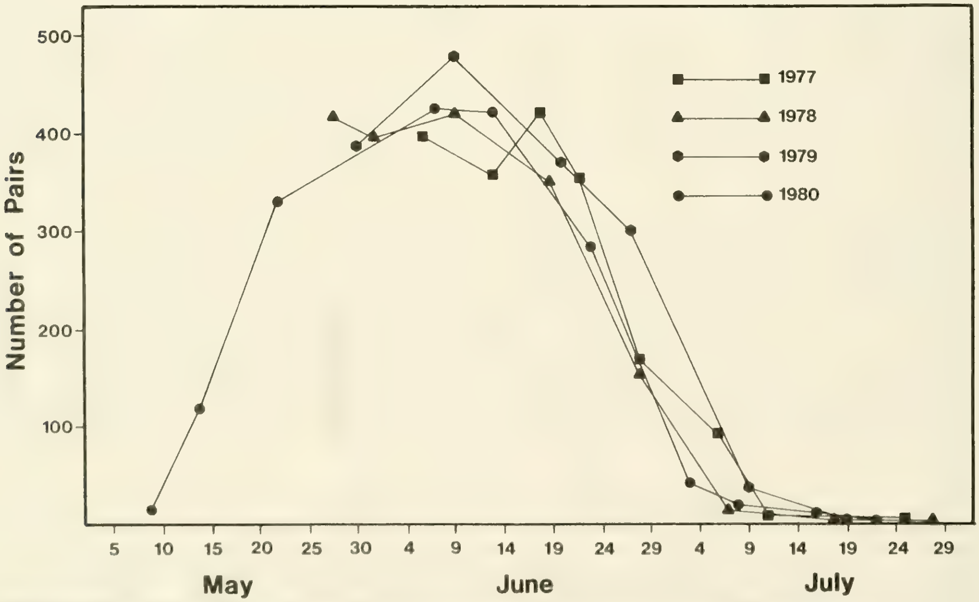

FIGURE 1. Numbers of White-winged Scoter pairs observed on Redberry Lake, Saskatchewan, 1977-1980.

TABLE 2. Number of White-winged Scoter nests in different types of vegetation dominant at the nest site on Redberry Lake, Saskatchewan, 1977-1980.

	1977	1978	1979	1980	All	
Habitat	N	N	N	N	N	%
Gooseberry	67	68	94	63	292	(67.6)
Reed	15	13	12	13	53	(12.3)
Forbs	7	9	11	18	45	(10.4)
Gooseberry-reed	1	6	5	2	14	(3.2)
Grass	0	0	9	0	9	(2.1)
Other shrubs	0	0	3	6	9	(2.1)
Gooseberry-forb	0	5	1	0	6	(1.4)
Reed-forb	0	1	2	1	4	(0.9)

Broods. Duckling mortality was greatest during the first week of life, and California Gulls were the principal predators of ducklings. In 28 observed gull attacks that were successful, 3 resulted in the destruction of entire broods, 8 resulted in losses of 2 to 4 ducklings, and in 17 cases a single duckling was killed. All successful gull attacks were directed toward single broods, rather than aggregate broods.

Based upon a comparison of known numbers of ducklings hatched (surely a low estimate because not all nests were found) and maximum number of ducklings in broods, an average of 65.8% of all ducklings hatched (range 59.9-72.3%) died in the first 7 to 10 days of life. Duckling numbers declined after 1 August even though most gulls left the lake and the older ducklings were much less vulnerable to gull attacks (Figure 2). We are uncertain of the cause of this mortality. We could not make accurate counts after about 15 August because ducklings began to disperse over the lake and their appearance and secretive behavior made it increasingly difficult to distinguish them from molting adults.

The two indices used to estimate productivity of the population (Table 4) were based upon the number of ducklings counted in the last brood census divided by: (1) the average number of pairs on the lake between 1 and 20 June and (2) the number of nests found on the islands. These figures should provide low and high estimates for the true productivity of breeding pairs because not all pairs nested and not all nests were found. Productivity was low every year and varied between 0.8 and 1.7 ducklings per nest and between 0.24 and 0.46 ducklings per pair. Our estimates for ducklings per breeding pair in Saskatchewan fell within the range of 0.02-0.60 ducklings per pair that was similarly calculated in Finland (Hildén 1964).

In 1979, 40% of all recaptured ducklings (N = 28) were web-tagged, suggesting that about 40% of the ducklings on Redberry Lake were hatched from island nests. This figure should be accurate if web tags were not lost and the capture technique (i.e. night-lighting) was unbiased. If 40% of all nests on the islands and mainland of Redberry Lake were found, then the total number of successful nests was about 330. When these figures are adjusted for the nest success rate on the islands (73.2%), about 450 females nested on Redberry Lake in 1979 (assuming nest and brood success rates were the same for island and mainland nests). Because breeding pair estimates approximated the estimated total number of nests, the index for ducklings per breeding pair should be a reasonable estimate of the productivity of the population.

Discussion

Arrival and Population Composition. White-winged Scoters arrive later at the nesting area and nest later than most other ducks that breed in the prairie pothole areas of North America (Hochbaum 1944; Bellrose 1980). Most scoters

TABLE 3. White-winged Scoter nest success in different nesting habitats on Redberry Lake, Saskatchewan, 1977-1980.

	Percent				
Habitat	Successful	Destroyed	Abandoned	Unknown	No. of nests
Gooseberry	73.6	10.3	14.4	1.7	292
Common Reed	84.9	9.4	5.7	0.0	53
Forbs	62.2	22.2	11.1	4.5	45
Other	66.7	16.7	16.7	0.0	42

TABLE 4. Mean clutch size, number of eggs hatched in successful White-winged Scoter nests, and production indices on Redberry Lake, Saskatchewan, 1977-80. Standard errors are shown in parentheses.

	1977	1978	1979	1980
Clutch	9.1 (0.24)	8.7 (0.24)	9.3 (0.22)	8.3 (0.19)
Number of eggs hatched	7.4 (0.27)	7.3 (0.22)	6.7 (0.26)	7.4 (0.25)
Date of initiation (June)	13 (0.82)	15 (0.76)	17 (0.60)	15 (0.66)
Date of hatch (July)	21 (0.83)	23 (0.72)	26 (0.59)	21 (0.19)
Number of nests	89	101	132	104
Ducklings/pair	0.37	0.23	0.38	0.22
Ducklings/nest	1.66	0.90	1.21	0.90

arrived at Redberry Lake between 14 and 22 May in 1980. The average date of first arrival for White-winged Scoters at Delta, Manitoba, over a 9-year period was 9 May (range 4 May to 14 May: Rawls 1949). White-winged Scoters first arrived at Miquelon Lake, Alberta, on 6 May in 1965 (Vermeer 1969). Only 44% of the females observed on Redberry Lake on 9 May 1980 were paired. Evidently, some pairing occurs during migration and on the breeding areas. Late pairing in White-winged Scoters is consistent with the general correlation found among acquisition of breeding plumage, pairing chronology, and nest initiation in several species of Anatini and Aythyini (Weller 1965) and with a generally later chronology of pairing found among Mergini compared to the Anatini and Aythyini (Bellrose 1980).

Numbers of scoters on Redberry Lake declined rapidly one to two weeks before the onset of hatching. Adult scoters may leave the lake after discontinuing reproductive attempts to avoid competition for food with ducklings, as suggested for other waterfowl (Salomonsen 1968; Trauger 1971). This behavior seems most likely for species that feed mainly on animal foods and are therefore most prone to competition for food. Changes in population composition of White-winged Scoters on Redberry Lake were similar to changes in breeding Velvet Scoters in Europe (Koskimies and Routamo 1953; Hildén 1964) and Lesser Scaups in North America (Trauger 1971). These species also exploit semi-permanent and permanent wetlands and feed mainly on animal foods (Bellrose 1980).

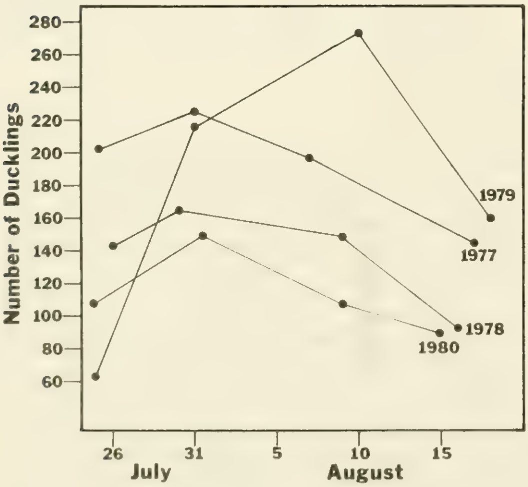

FIGURE 2. Numbers of White-winged Scoter ducklings counted on Redberry Lake, Saskatchewan, 1977-1980.

Scoter numbers changed little among years on Redberry Lake. Scoters typically breed on large marshes and lakes that are relatively stable compared to smaller, shallower wetlands. The predictability and availability of wetlands used for breeding by a waterfowl species probably influences the magnitude of yearly changes in local breeding populations. Habitat variability in the prairie pothole region influenced the relative abundance of dabbling and diving duck guilds (Nudds 1983). Lesser Scaup nesting near Yellowknife, Northwest Territories, used ponds that fluctuate less in water level than prairie habitats on an annual basis (Wellein and Lumsden 1964), and scaup numbers showed little variation (Murdy 1964; Trauger 1971). Conversely, Mallards and Northern Pintails that nested on prairie pothole habitat near Kindersley, Saskatchewan, showed marked population changes over a 12-year period (Dzubin 1969). Species that are more K-selected in their breeding strategy often exploit more predictable environments than more r-selected species, and their populations are less variable (Pianka 1974). White-winged Scoters are more K-selected than most ducks and they use relatively predictable and stable large marshes and lakes for breeding.

Nest Sites and Nest Success. The most consistent characteristic of White-winged and Velvet scoter nests is that they are located in extremely dense, often thorny cover (Bent 1925; Rawls 1949; Koskimies and Routamo 1953; Hildén 1964; Vermeer 1969; Brown and Brown 1981). Selection of the nest site probably has evolved to enhance protection of the nest (Hildén 1965), but it also may involve protection of the female from predators. Scoter nest densities are greatest on islands (Koskimies and Routamo 1953; Hildén 1964; Vermeer 1968, 1969; Brown and Brown 1981), and nests on mainland sites and large islands are often located long distances from water (Keith 1961; Brown 1977; Bellrose 1980; Brown and Brown 1981).

The relatively low and slow take-offs of seaducks (especially large-bodied seaducks) may make them particularly vulnerable to mammalian predators. Selection of exceptionally concealed and safe nest sites is a common characteristic of seaducks. Five of 15 species of Mergini in North America nest in tree cavities and seven species usually nest on islands or islets (Bellrose 1980). Of the remaining three species, two nest long distances from water and in very low densities. Dispersal of nests away from the shoreline and use of islands for nesting may reduce the vulnerability of the female and her clutch to mammalian predators.

White-winged and Velvet scoters often nest in association with larids (Hildén 1964; Vermeer 1968; Brown and Brown 1981). On Redberry Lake, the strength of this association seemed only moderate, as described for Velvet Scoters (Hildén 1964). The attraction may result from the overlap of suitable nesting habitats (i.e. both species nest on islands, and dense gooseberry bushes were most common within the gull colonies). On Jessie Lake, Alberta, scoters nested in high densities, but no gull nests were present (Brown and Brown 1981). Scoter nest site selection seems to be influenced more by nest concealment and previous nest success, whereas the presence or absence of larid colonies is less important.

Dense nest cover was advantageous because nests that were completely concealed had lower rates of destruction than those in sparser cover (Table 3). Dense nest cover is particularly important for White-winged Scoters because of their long egg-laying interval (1.4 to 1.6 days per egg) (Koskimies and Routamo 1953; Vermeer 1969; Brown and Brown 1981) and their pattern of declining nest attentiveness during incubation (Brown and Fredrickson 1987). Nests were particularly vulnerable to avian predation when females were away from the nest; most nests destroyed were in egg-laying or late in incubation when females were off the nest a large proportion of the day (Brown and Fredrickson 1986).

Nesting Chronology. The low variation in scoter nesting chronology among years may be related to the consistency in the annual pattern of abundance in their primary food, *Hyalella azteca*, an amphipod, and other invertebrate foods (Cooper 1965; Rawls 1949; Brown and Fredrickson 1986) in large marshes and lakes. Laying dates, clutch sizes and egg weights of scoter females did not vary with increasing experience. Similar results were reported for Velvet Scoters (Koskimies 1957a, b) and Mallards (Batt and Prince 1978, 1979; Batt 1979). The negative correlation of clutch size and laying dates in White-winged Scoters may occur because it is advantageous for nests to hatch in a narrow range of dates. Late nests must have smaller clutches to hatch in the most advantageous time. Most Velvet Scoters' eggs also hatched during a short interval (Koskimies and Routamo 1953).

Nesting chronology varies among the Mergini and probably varies with the timing of habitat and food availability, and the associated bioenergetic strategy to meet reproductive demands. For example, Common Eiders (*Somateria mollissima*) rely heavily upon stored reserves to meet reproductive demands (Korschgen 1977). The heavy reliance upon stored reserves may be necessary for eiders to nest successfully in the marine environment because of intense predation pressures on nests by gulls (Bourget 1973). Use of endogenous reserves allows eiders to lay eggs faster than would otherwise be possible. Eiders typically lay eggs at a rate of one per day, much faster than most seaducks (Bellrose 1980). White-winged Scoters rely mainly upon dietary resources to produce the clutch, and their later breeding season coincides with peaks in growth and abundance of their most important food source, *Hyalella azteca* (Brown and Fredrickson 1986).

Genetic variation in clutch size, laying date, and egg weight probably occurs because natural environments are temporally and spatially variable, and because the fitnesses of different genotypes are themselves variable (Batt 1979). In Snow Geese (*Anser caerulescens*), a range of egg-weight genotypes persists because of annual variation in environmental conditions at hatch (Ankney and Bisset 1976). A similar hypothesis could be applied to egg-weight variation in White-winged Scoters.

For scoters nesting at Redberry Lake, nesting chronology might be partially influenced by the time of gull dispersal and by weather conditions during the brood-rearing period. Because gulls disperse from breeding colonies between 20 July and 3 August (Vermeer 1970), early-hatched broods may experience greater gull predation than broods hatched later. But ducklings hatched earlier spend more of the development period during moderate temperatures. Broods from later clutches may suffer fewer losses to gulls, but the 10-week development period forces ducklings to spend more of their growth period during cooler weather. Mild weather conditions during brood-rearing may favor late nesters, but cold, rigorous conditions later would favor early nesters.

Also, early-nesting females may be able to put more of their endogenous reserves into the eggs, because they have more time to replenish their reserves after nesting in preparation for the molt and southward migration. At the end of incubation, females lost 25% of their peak body weight and had low body fat levels (Brown 1981). Females that nest later may have less time to replenish reserves before the molt and migration and may have evolved a smaller clutch to conserve their reserves.

Egg Success. The rate of egg failure (18.1%) in successful White-winged Scoter nests was much greater than that reported for Velvet Scoters (5.0-8.8%) (Hildén 1964; Koskimies and Routamo 1953) and most other ducks (Bellrose 1980). The unusually poor egg viability found in central Saskatchewan warrants further study. Environmental pollutants could be picked up in breeding, wintering or migration habitats. One of eight White-winged Scoters analyzed for PCB and trace metal content in northern New York had high levels of PCB and another had elevated lead levels (Baker et al. 1976). Scoters nesting at Redberry Lake winter on both eastern and western coasts of North America (Houston and Brown 1983) and could be exposed to pollutant levels similar to scoters collected in New York.

Brood Behavior and Duckling Survival. Female White-winged Scoters usually abandoned their broods within two weeks of hatching, and aggregate broods were common (Brown and Brown 1981). Only a few females remained with broods longer than two weeks. Females of most seaduck species desert their young before they mature to flight stage and combination of broods occurs in 9 of 15 species in North America (Bellrose 1980).

Duckling survival was low every year of this study. High duckling mortality was documented for White-winged Scoters on Redberry and Jessie lakes (Brown and Brown 1981), and for Velvet Scoters in Finland (Koskimies 1955; Hildén 1964), where 90-95% of all ducklings perished in years with the best survival. Initially, Koskimies (1955) believed that the mortality resulted from low cold-tolerance of the ducklings combined with cold and wet weather during the brood season. Later, Koskimies and Lahti (1964) demonstrated a high degree of cold-hardiness in Velvet Scoter ducklings and suggested that ducklings do not die directly as a result of the inclement weather. They believed that the ducklings' cold tolerance resulted from a high metabolic rate relative to body size (Koskimies and Lahti 1964).

Nightly temperatures often decline to just above freezing after mid-August at Redberry Lake, increasing the energy costs of maintenance for ducklings. Also, this period corresponds to the time of greatest energy demand for the growing ducklings (Brown and Fredrickson 1983). Ducklings feed upon similar foods as adults, and feed by diving, which is an energetically expensive behavior (Brown and Fredrickson 1986).

The long development period of ducklings may be an adaptation to reduce daily energy requirements (Brown and Fredrickson 1983). Duckling survival may be low because they must balance demands of growth and maintenance, while their ecological niche produces a low net energy level mode of life (Brown and Fredrickson 1983). Although adult female scoters on Redberry Lake have high longevity (Brown and Houston 1982), the high mortality rate of ducklings documented on Redberry Lake, Jessie Lake, Alberta (Brown and Brown 1981), and in Europe for Velvet Scoters (Hildén 1964; and others) suggests that populations are unlikely to increase rapidly even under favorable conditions.

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Diurnal and Seasonal Patterns of Colony Attendance in the Northern Fulmar, *Fulmarus glacialis*, in Alaska

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The annual cycle of Northern Fulmars (*Fulmarus glacialis*) in the western Gulf of Alaska includes about six months from mid-April to mid-October when birds are associated with land at the Semidi Islands. The pre-laying stage in five years was marked by recurrent peaks in attendance that included up to 90% of the population, and alternate periods of 2 to 12 days when the breeding ground was deserted. Serial correlation of daily attendance indicated a cyclic pattern with a half-period of five to seven days. Maximum attendance at breeding sites usually occurred in the evening after a gradual increase in numbers during the day. Percentage of attendance by nonbreeding and failed birds varied widely with breeding success, but the seasonal occurrence of nonbreeders followed a consistent pattern: attendance by site-holding nonbreeders peaked before egg-laying, then steadily declined, whereas an influx of nonbreeding floaters occurred in July and August. Different wind directions and speeds influenced the number of birds at the colony for up to three days after they occurred, but it was not possible to explain the birds' behaviour during the pre-laying period in terms of simple linear relationships between attendance and weather. Rather, synchronized attendance appeared to be a social phenomenon mediated by environmental cues such as a change in wind direction.

Key Words: Northern Fulmar, *Fulmarus glacialis*, colony attendance, weather effects, time-series analysis, Alaska.

Information on patterns of colony attendance is essential for developing effective census procedures for seabirds (Lloyd 1975; Nettleship 1976). Such data are also of ecological interest since they describe important features of the annual cycles and social systems of colonial species. Few definitive data have been published on patterns of colony attendance in petrels (Procellariidae), though there have been a number of detailed studies of breeding biology in this group (e.g., Richdale 1963; Harris 1966; Pinder 1966; Serventy 1967; Imber 1976; Warham et al. 1977). Undoubtedly, that is because most species nest in burrows and are nocturnal on land. The Northern Fulmar, *Fulmarus glacialis*, is better suited to the detailed study of attendance patterns because of its diurnal, cliff-breeding habits.

From 1976 to 1981 I studied the population dynamics, breeding ecology, and behaviour of Northern Fulmars at the Semidi Islands (56°N, 156°W), one of four major breeding locations of the species in the northeastern Pacific. Here, I describe the major diurnal and seasonal patterns of colony attendance, both in terms of overall numbers and in relation to the breeding status of the birds present. I also examine the influence of weather on day-to-day changes in numbers.

Methods

Field Techniques

In addition to making daily counts of birds on study plots and all-day watches to determine diurnal changes, I made observations on individual breeding sites to determine attendance patterns among birds of known breeding status (breeding, nonbreeding, failed, pre-laying). All study plots and individual breeding sites were on a 2-km expanse of cliffs on the west side of Chowiet Island, an area of representative habitat occupied by about 40 000 of the estimated 440 000 fulmars on the Semidis (Hatch and Hatch 1983). Observations in five years spanned a four-to-five month period from three to eight weeks before egg-laying through late August or early September, when the oldest young were still about a week away from fledging; in 1978, the study was limited to the period 24 May to 29 June, which encompassed egg-laying and early incubation.

From 500 to 700 breeding sites were included in the study plots used to monitor overall attendance, depending on the year (eight plots in 1976-79, six plots in 1980-81). Counts of single birds and pairs on those plots were generally made between 0900 h and 1600 h. During eight all-day watches from 10 May to 21 August 1977, single birds and pairs were counted at 15-min intervals on one plot of about 130 breeding sites.

The sample of individually monitored breeding sites included 292 sites in 1976 and 540 to 550 sites in later years. Many of those sites were on the plots already described; others were in similar habitat off the plots. Sites were numbered and identified in photographs for permanent reference. Information recorded on daily visits included attendance of adults (0, 1, or 2 birds present) and the presence or absence of an egg or chick. A breeding pair of fulmars produces only one egg a season.

For analyses that concerned the relative proportions of breeding and nonbreeding birds, I included only sites selected before eggs were laid to avoid an over-representation of breeding birds in the sample. Thus, most of the information presented is based on a sample of 217 sites in 1976 and about 425 sites in all other years. Apart from a few deletions or additions of sites in the early years, the same sample was used throughout the study. All observations of sample plots and individual sites were made from a distance using binoculars or spotting scope, and attendance appeared to be unaffected by my presence.

Fulmars occurred in a continuous gradation of colour phases, but for purposes of record-keeping I classified birds into four groups, denoted LL, L, D, and DD, following Fisher (1952). About 82% of the birds on the Semidis were DD, whereas a majority of breeding sites chosen for study included at least one bird in the rarer LL, L, or D plumage categories. Thus, the occasional occurrence at breeding sites of individuals other than the usual residents was partially accounted for in the analysis. Otherwise, I assumed that a bird seen at a site in which an egg eventually was laid was a future breeder, and that a bird in a site from which an egg or chick had been lost was a failed breeder.

Birds that regularly occupied a particular site I call site holders. Birds that did not produce an egg were nonbreeders, a category that included about 17% of all site holders (Hatch 1987). I use the term "floaters" for birds that did not acquire mates or take possession of breeding sites in a given season, and I refer collectively to birds not engaged in incubation or chick-rearing (failed or nonbreeding) as unemployed.

Weather parameters recorded two or three times a day included wind speed (estimated to ± 5 knots from sea surface conditions), wind direction (compass bearing), cloud cover, visibility, and the presence or absence of fog. Maximum and minimum air temperatures, precipitation, and barometric pressure were recorded daily.

Data Analysis

On a few foggy days it was not possible to obtain counts for all study plots. The totals for those days were prorated according to the average contribution to the total of each plot or combination of plots missed so that all daily counts could be compared.

Floaters were recognized during extended behaviour watches by their lack of attachment to any particular breeding site on the cliffs. No attempt was made to count floaters separately during routine counts, but their numbers were estimated indirectly by combining information from the plot counts and individually monitored sites. First, I estimated the number of breeding pairs on the study plots by dividing the number of chicks produced (an easy determination to make at the end of the season) by the rate of breeding success observed in my sample of individually monitored breeding sites. I then expressed daily attendance in breeding sites as birds per egg laid and applied that ratio to the daily counts of birds on study plots. This provided an "expected" value for attendance by site holders. The difference between expected values and the actual counts was an index of floaters on the study plots.

To test whether a given series of attendance counts exhibited periodicity, I calculated serial correlation coefficients and plotted an autocorrelation function. Each plotted coefficient (r_s) is a correlation between pairs of observations separated by a lag interval (s) of 1 to 25 days. An autocorrelation function that became significantly negative for some values of s was taken as evidence of regular oscillations in the time series. For example, a negative correlation at $s = 5$ would indicate that low and high counts tended to occur five days apart. The interpretation of autocorrelation functions was based on definitions and guidelines provided by Pielou (1974).

Results

Seasonal Occurrence on Study Plots

The first landings by fulmars at their breeding sites in spring were observed only in 1981. Birds were abundant in the area on most days in early April that year, but they tended to stay 1-2 km offshore, flying low over the water or sitting in large rafts. Thousands finally approached the cliffs and landed en masse on the evening of 11 April. The first egg was laid on 31 May in 1981, 50 days after the first landfall. That interval may be fairly characteristic, since other features of the annual cycle were quite similar in all years (Figure 1).

Attendance during the pre-laying period was marked by sharp peaks in the number of birds on land, alternating with intervals of total absence for 2 to 12 days. Birds apparently travelled a considerable distance from the islands on foraging trips because I frequently was unable, using a spotting scope, to see any fulmars over the water during one of the periods of absence. In contrast, the pre-laying peaks of attendance included about twice as many birds as occurred at any time after the start of laying and incubation. From that point onward, a gradual decline in average attendance was evident most years.

Diurnal Rhythm

A gradual increase in numbers during the day was observed early in the season (pre-laying to

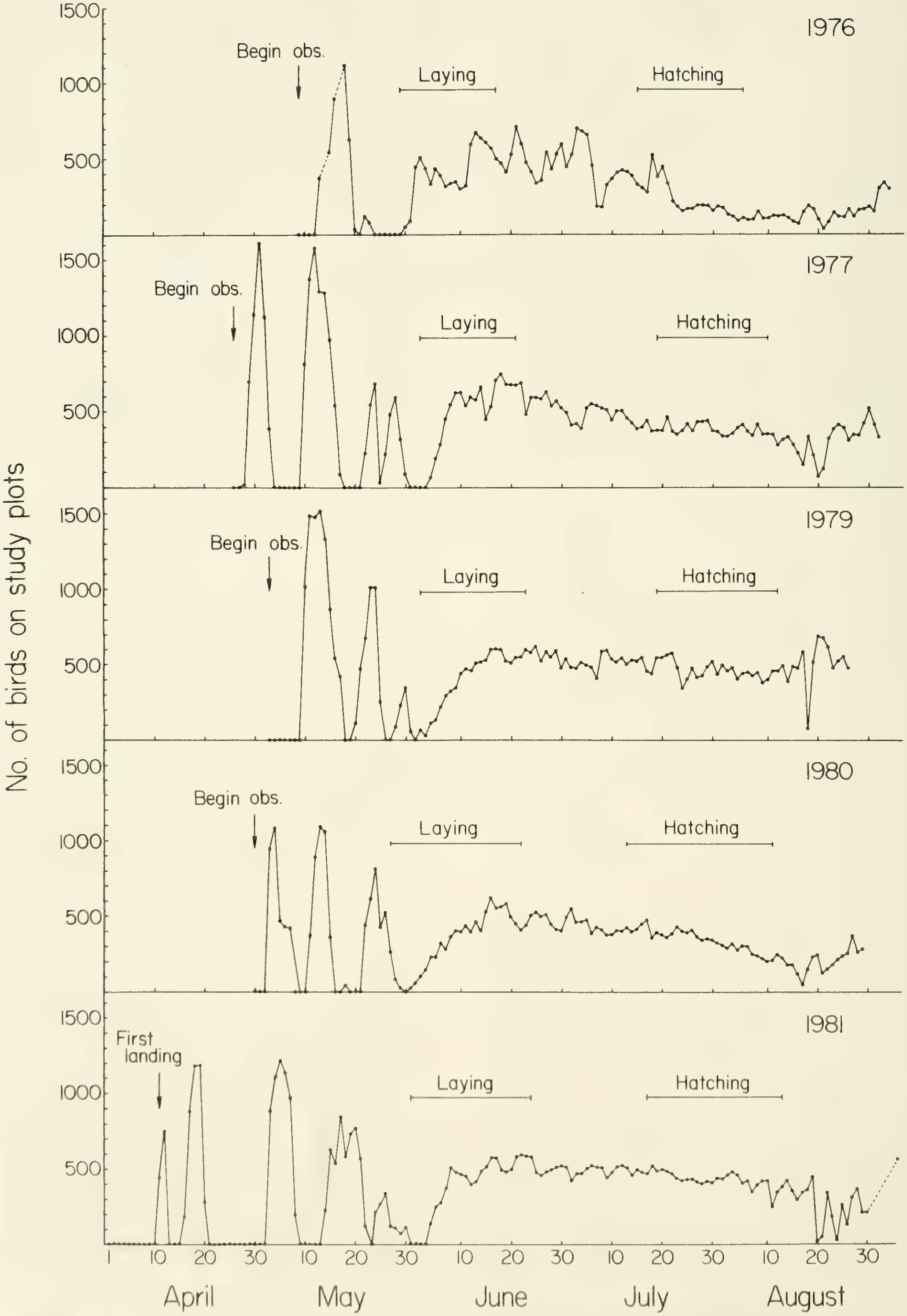

FIGURE 1. Seasonal patterns of attendance on study plots by Northern Fulmars during five years at the Semidi Islands. The final count in 1981 was made after a hiatus of six days.

mid-incubation), with maximum attendance occurring in the evening (Figure 2). During hatching and the early chick period (12 July to 5 August) there was no clear pattern except a rise in numbers early in the morning and a corresponding drop at dusk. The wide diurnal range in attendance observed on 21 August reflected in part the greater mobility of parents once their chicks no longer required constant brooding. However, the pattern observed that day was also exceptional in that it followed a strong gale on the previous day, during which nearly the entire adult population had evacuated the cliffs.

Maximum counts during the first seven all-day watches ranged from 204 birds on 10 May to as few as 76 birds on 22 July. Minimum counts, generally those made soon after dawn, were 60 to 80% of daily maxima. Thus, variation in colony attendance between days was usually much greater than variation within days. Considering only that portion of the day when daily counts were made (0900 h to 1600 h), the average change in attendance within days was +11% (range 0 to 26%), whereas the mean counts for the same seven days differed by 123%.

Attendance and Breeding Status

The pattern of attendance during the pre-laying period was similar in all years. For example, in 1977, about 90% of breeding-site holders were present on days of peak attendance in the pre-laying stage (Figure 3a). Actually, the proportion was even higher because the calculation is based on two birds in every breeding site constituting 100% attendance, whereas some sites were never seen to be occupied by more than a single, possibly unmated bird. The patterns depicted for 1977 typify those recorded in other years.

After 1 June, both the overall level of attendance and the composition of the population depended on the level of breeding success in a particular year (Figure 4). The data for 1976 and 1981 show the extremes (15% success in 1976 versus 72% success in 1981). A third graph in Figure 4 shows the average composition observed in five years (omitting the incomplete data for 1978). At no time after the start of egg-laying did the number of birds on the cliffs comprise more than about 50% of the known population of site holders; the highest proportion was only 35% in 1976.

The number of birds actively engaged in incubation or chick-rearing steadily declined as unsuccessful pairs joined the ranks of failed breeders. Otherwise, attendance by breeders was relatively constant, and daily fluctuations in colony attendance after 1 June resulted mainly from the movements of failed and nonbreeding birds ($r = 0.94$, on average, for the correlation between overall attendance and the number of failed and nonbreeding birds present, compared with $r = 0.56$ for the relationship between number of active breeders and total attendance).

The proportion of nonbreeders in my sample of breeding sites averaged 17.3% over five years, whereas only about 5% of experienced birds (i.e., those that had bred at least once before) skipped breeding annually (Hatch 1987). Nonbreeders made up about 20% of the birds at breeding sites on most days during the pre-laying period (Figure 3a), but usually comprised no more than about 10% over the remainder of the season (Figure 4). The largest number of nonbreeders in any one count invariably occurred in the first half of May.

After 1 June there were no days on which most or all of the nonbreeders were present at one time, as was the case in May, so the following approach was used to reveal seasonal changes in the number of nonbreeders visiting the colony. I selected data for nonbreeders of known identity (i.e., individuals of the rare plumage types: LL, L, and D) and calculated the percentage of birds that visited their sites at least once during a running 10-day interval, incremented one day for each calculation (Figure 5a).

Five-day means are plotted to smooth the curve, but the maximum value observed in each five-day interval is also given since the pre-laying value used to represent full attendance (100%) was itself a single, maximum count. The clear result is a population of nonbreeders at breeding sites during most of June that was little changed from the pre-laying period, followed by a steady decline to about 40% of the pre-laying maximum by the end of August.

The above information on attendance at breeding sites does not take nonbreeding floaters into account. I estimated that total nonbreeders (site holders and floaters) made up 30-35% of the population of fulmars around the islands in spring, nearly double the number associated with breeding sites (Hatch 1987). Floaters tended to alight wherever they were tolerated by site holders and were little inclined to spend time sitting in established breeding sites, even when the residents were away. The largest number of nonbreeding floaters occurred before egg-laying, so I again plotted five-day means and maximum values relative to the highest value estimated for the pre-laying period (Figure 5b).

The lack of highly synchronized attendance among floaters after egg-laying explains why all plotted values after 1 June are small in relation to the pre-laying maximum. The major finding was that a downward trend in the floating population occurred in June and July, followed by a sharp increase during August. In fact, that influx appeared earlier each year as an increasing number

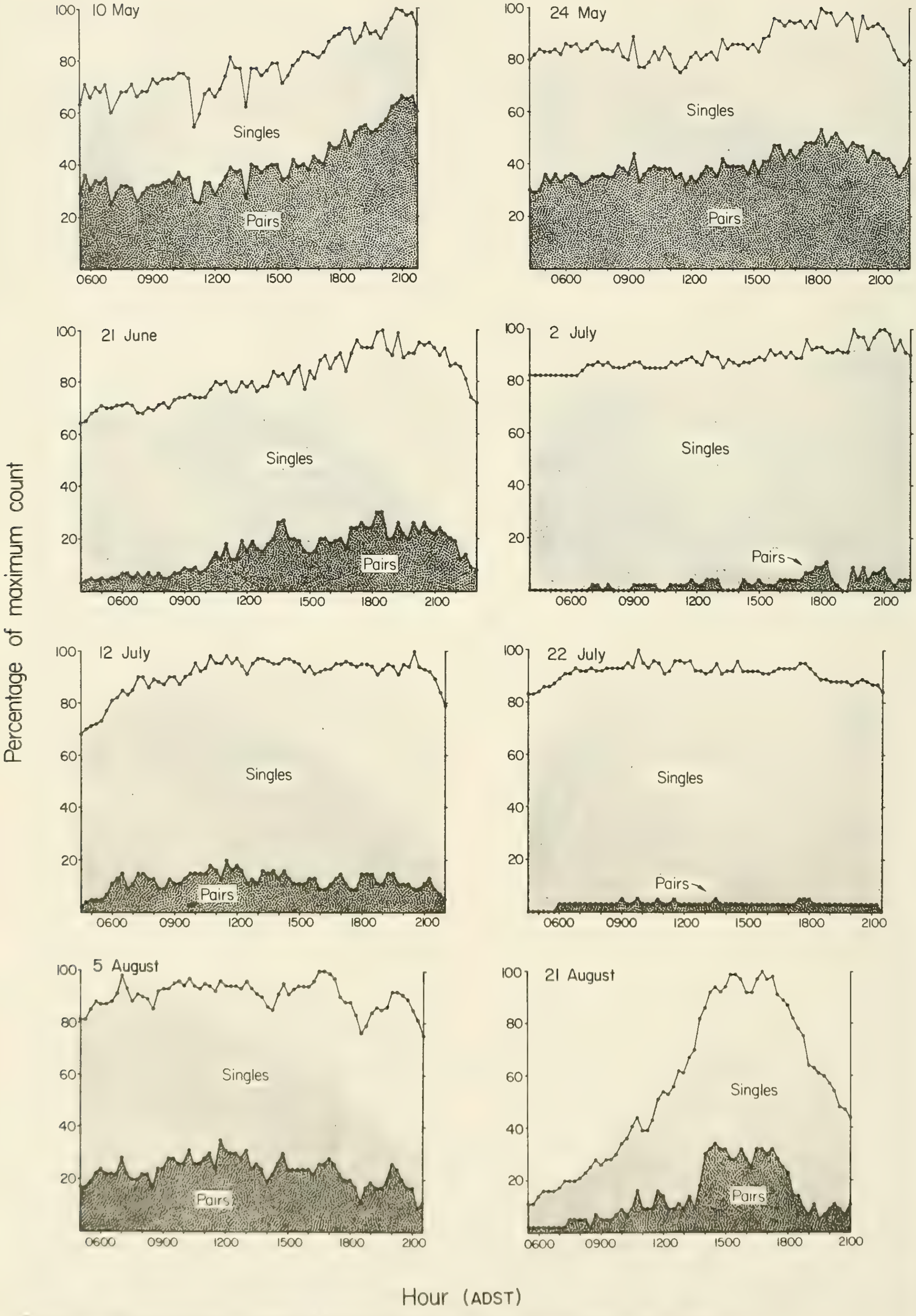

FIGURE 2. Diurnal rhythm in breeding site attendance by Northern Fulmars on eight days in 1977.

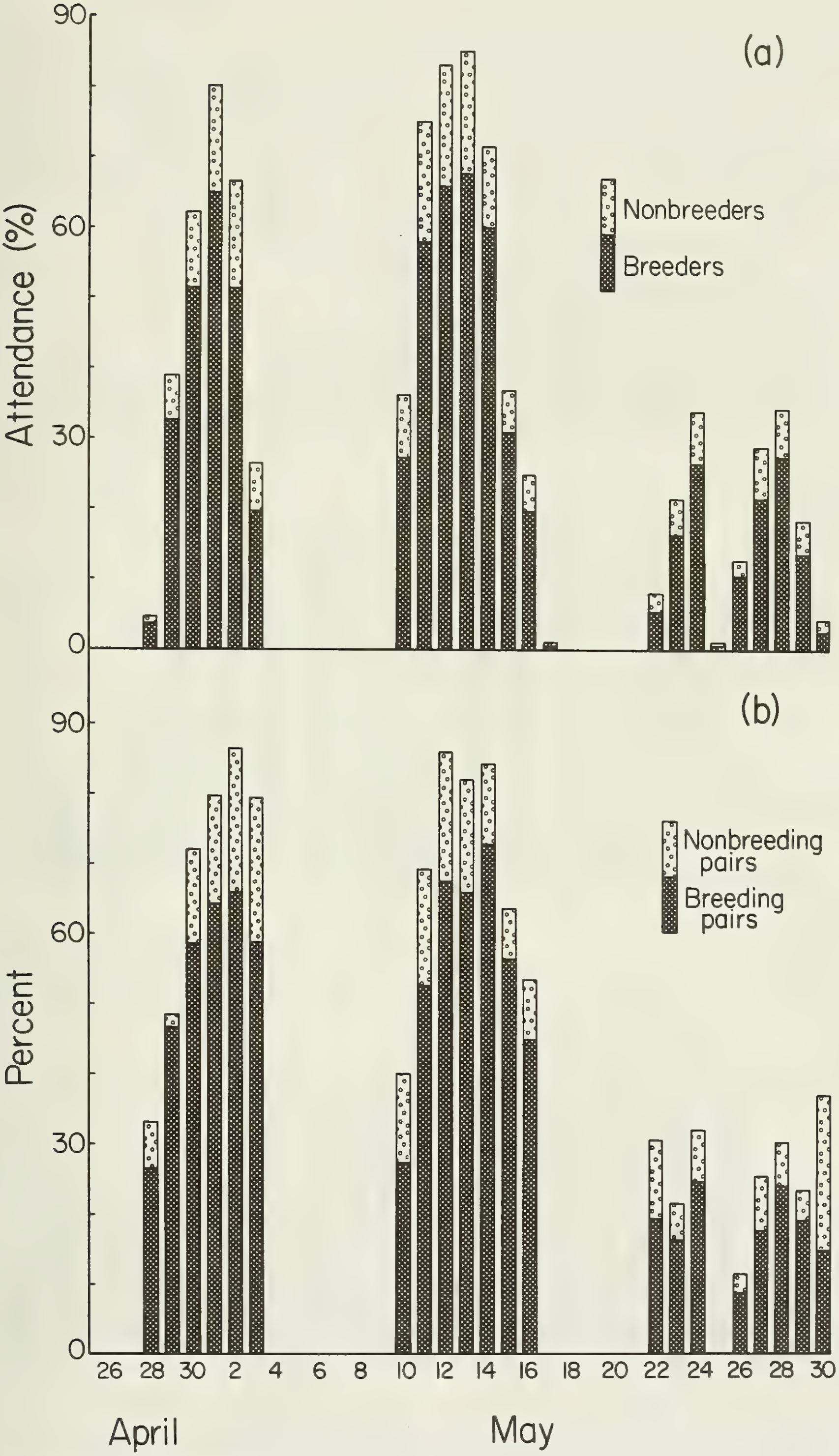

FIGURE 3. Attendance patterns during the pre-laying period in 1977: (a) proportions of total breeding and nonbreeding site holders present (two birds per site counted as 100% attendance) and (b) percentage of occupied sites containing pairs.

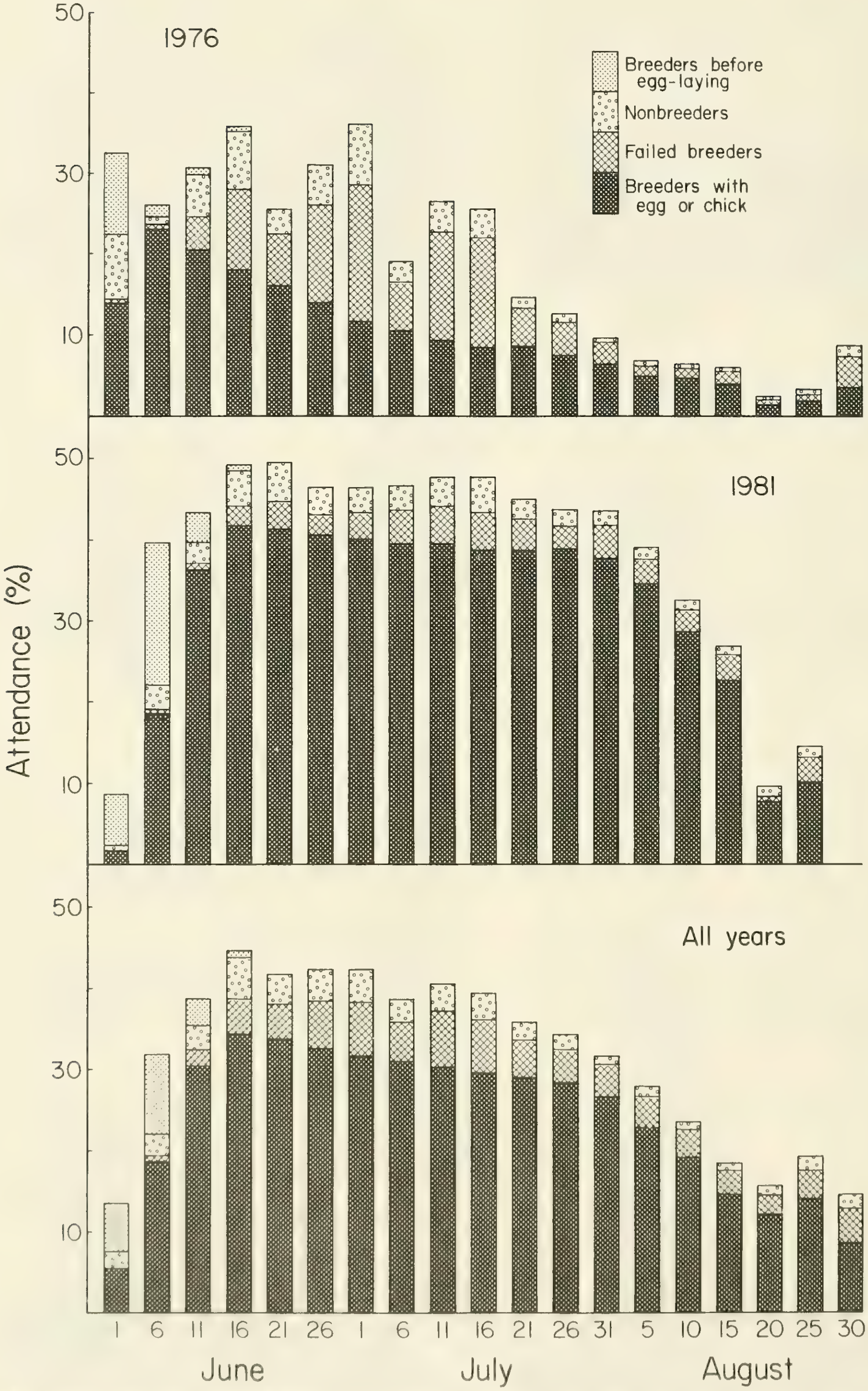

FIGURE 4. Attendance and breeding status of Northern Fulmars in two years with contrasting levels of breeding success (1976 and 1981) and a generalized pattern based on an average of five years. Bars represent average daily attendance at breeding sites in five-day intervals beginning on the dates indicated. Two birds in every site constituted 100% attendance.

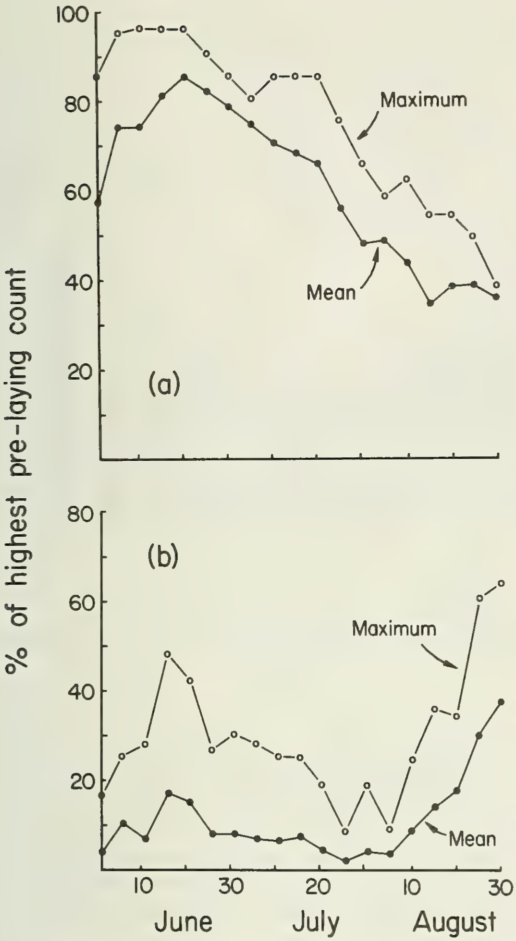

FIGURE 5. Seasonal trends in attendance after 1 June by (a) nonbreeding Northern Fulmars in established sites and (b) nonbreeding floaters on study plots. See text for an explanation of the analysis.

of birds in the air around the cliffs and over the water beginning about mid-July. Figure 5b illustrates the timing with which the new arrivals began to spend time on the ground.

Occurrence of Pairs

The percentage of occupied sites containing pairs tended to follow a pattern similar to that of overall attendance. About 90% of occupied sites contained pairs on days of peak attendance during the pre-laying period (Figure 3b), whereas only 6-10% had pairs in June and July (Figure 6). All but a small fraction of the pairs observed during incubation and the early chick stage were failed or nonbreeding pairs, because breeders rarely spent more than a few minutes with their mates when changing shifts of incubation or brooding. Over the 48-day incubation period, a given breeding pair was observed at their site an average of only 1.1 times during my daily visits. Once a chick no longer required constant brooding or protection, however, its parents were often away or present at the site for overlapping periods of time. Thus, the proportion of sites containing pairs with chicks steadily increased in late July and August.

Time Series Analysis

Since the attendance patterns of breeders were tightly constrained once breeding had begun, the time series chosen for analysis in this and the following section was the daily percentage attendance of failed and nonbreeding birds. I arbitrarily truncated the series in late July or early August, depending on the year, because too few unemployed birds remained after that time to give meaningful results.

Autocorrelation functions suggested cyclic patterns of attendance in four of the five years, with periods ranging from 10 to 15 days (Figure 7). As would be expected, large fluctuations in attendance during the pre-laying period had a strong influence. Only in 1976 and 1977 did r_s have significantly negative values (at a lag of five days in both years) for the series beginning 1 June, whereas all years (including 1981) exhibited significant periodicity in the series ending 1 June.

Attendance and Weather

The correlation between wind speed and percent attendance by failed and nonbreeding birds was weakly negative ($r = -0.09$, $P < 0.05$, d.f. = 487). Wind direction had a stronger effect than wind speed when the observations were grouped into four categories: NE, SE, SW, and NW winds ($P < 0.001$, one-way ANOVA, multiple $R = 0.28$). Days with northerly winds had lower average attendance than days with southerly winds, but unplanned comparisons of means revealed no significant differences between the effects of NW and NE winds or between SW and SE winds.

Increased cloud cover was also positively correlated with attendance ($r = 0.20$, $P < 0.001$, d.f. = 487), but the effect was not significant after controlling for the effect of wind direction. Cloudiness was strongly associated with southerly winds at the Semidis, whereas clear weather occurred when the wind blew from the north. It seems likely that fulmars responded more to wind direction than to cloud cover per se. None of the other weather variables examined (maximum daily temperature, barometric pressure, precipitation, and fog) had a significant effect on attendance.

The above correlations for wind speed (r^2) and direction (R^2) indicate relatively minor effects of weather conditions on attendance (only 8% of the variability was explained by wind direction, and

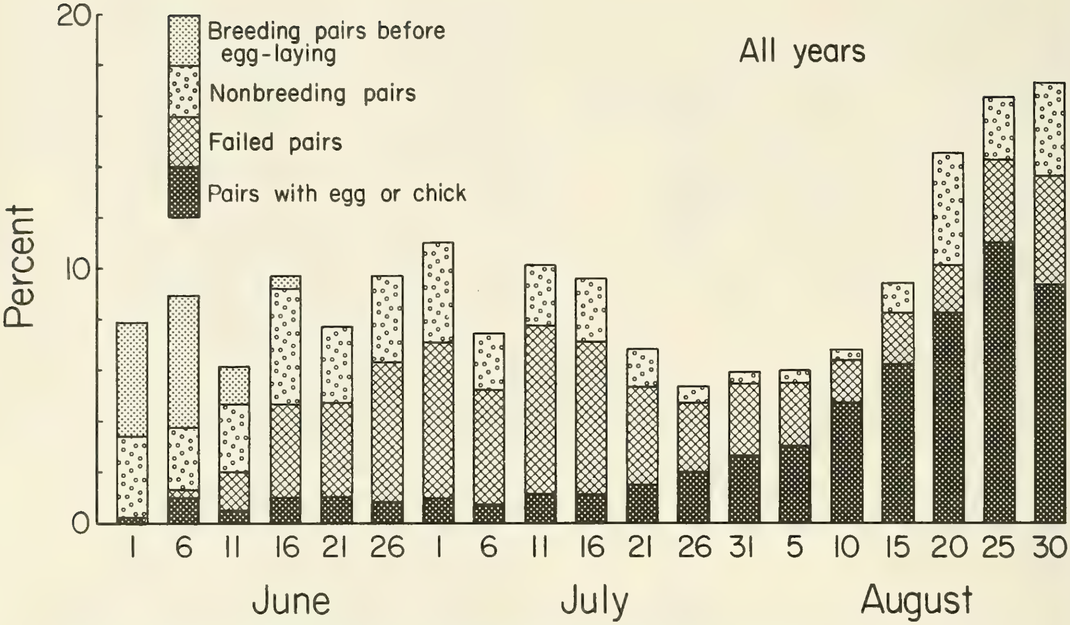

FIGURE 6. Occurrence of pairs in relation to breeding status (percentage of occupied sites containing pairs). Bars represent mean attendance in five-day intervals beginning on the dates indicated.

less than 1% could be attributed to wind speed). The effects were detectable mainly because of the large sample sizes available for analysis (n = 492 days over six years).

However, the most notable responses to weather appeared to be nonlinear, since the mass departures and arrivals in the pre-laying period were often associated with a marked change in weather conditions. To illustrate, I identified 16 obvious "spikes" in the attendance patterns observed before 1 June (Figure 1). The first day of attendance after an absence of one or more days I treated as day 0 and calculated average weather conditions on the two previous days, on the day of return, and on the following two days. The conspicuous transition in weather conditions associated with the return to land was a shift from northerly to southerly winds, increasing clouds, and rain (Table 1).

Throughout the breeding season, fulmars made foraging trips lasting several days. Therefore, the effect on attendance counts of a change in weather conditions would be expected to last for several days. To test that possibility, I compared means of attendance on day *i* resulting from different conditions of wind speed or direction on each of the five preceding days. Attendance was still significantly depressed up to three days after a strong wind (>10 knots), and two days after a north wind (Table 2).

Finally, I considered the possibility that cyclic changes in weather conditions could account for cyclic patterns of colony attendance by fulmars. Among four weather variables whose autocorrelation functions were examined (wind speed, wind direction, barometric pressure, and cloud cover), barometric pressure was cyclic (rather strongly so) in 1976, but with a period of 20 days instead of the 15-day period observed in attendance. Other variables exhibited no patterns comparable to the functions plotted in Figure 7.

Discussion

The interval between first landing and egg-laying in 1981, about seven weeks, was similar to the pre-laying period observed in several other petrels (e.g., Davis 1957; Pinder 1966; Serventy 1967). Although I did not determine the timing of final departure in the fall, it seems unlikely that adults remain on land at the Semidis for any appreciable time after the young are fledged. Information from the Pribilof Islands (57°N, 170°W) indicated that fulmars had all but disappeared from the cliffs there by late September or early October (Preble and McAtee 1923).

The diurnal range of attendance on the cliffs varied with the proportion of birds that were able to come and go freely (i.e., failed and nonbreeding birds and parents of older chicks), but a recurring pattern was for maximum numbers to occur in the

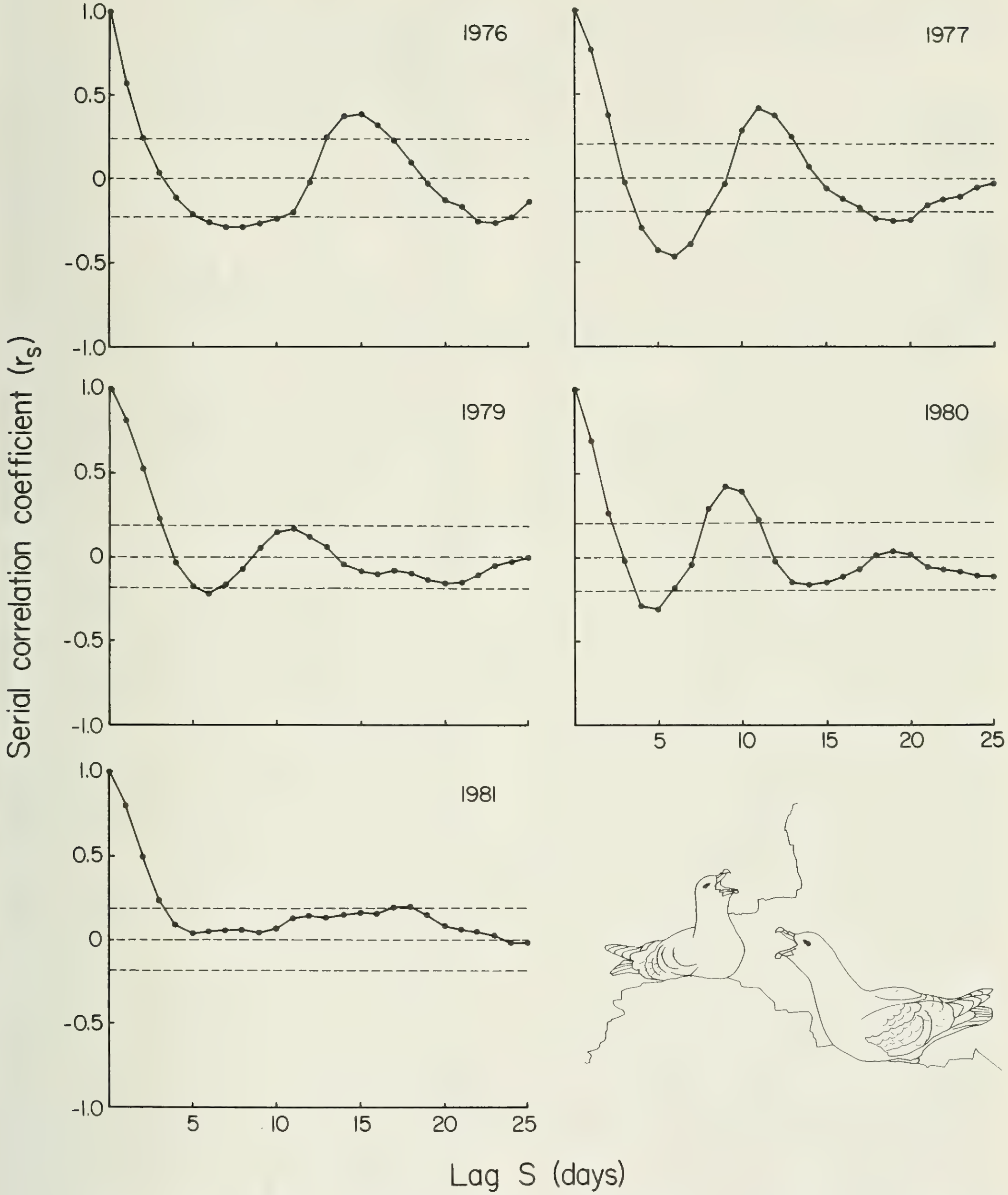

FIGURE 7. Serial correlation of daily attendance counts (failed and nonbreeding birds only) from pre-laying through late July or early August in five years. Upper and lower broken lines define an approximate range of ± 2 SE around the 0 value.

early evening (Figure 2). The drop in numbers observed just before dark on most days is consistent with the finding that fulmars feed largely at night, at least at certain times of the year (Furness and Todd 1984; Hatch, unpublished data). Even under conditions of continuous daylight, however, fulmars at Jan Mayen Island (71° N, 80° W) exhibited a diel rhythm of colony attendance, with a lull in activity and partial evacuation of the cliffs around midnight (Cullen 1954; Moss 1965).

A pattern frequently observed in petrels and

TABLE 1. Changes in weather conditions associated with a return of fulmars to land after an absence in the pre-laying period.

	Days before or after return				
Variable	−2	−1	0	+1	+2
Number of days	16	16	16	16	16
Days with N wind	10	5	1	2	4
Days with S wind	4	8	13	10	9
Calm days	2	3	2	4	3
Average wind speed (knots)	14.4	13.8	15.4	14.7	15.2
Barometric pressure (mbar)	1014	1015	1013	1011	1012
Rainy days	6	5	10	12	11
Average rain/day (mm)	0.5	0.9	3.7	2.4	3.0
Average % cloud cover	44	58	80	84	70

other seabirds is for young, prospecting birds to arrive at the colonies later in the season than established breeders (Nelson 1966; Serventy 1967; Fisher and Fisher 1969; Harris 1983). Dott (1973) observed an influx of molting fulmars to a British colony in July and August and surmised that the arrivals were nonbreeding and failed birds that had just completed primary molt at sea. My data agree with Dott's interpretation but also emphasize the importance of distinguishing site holders and nonbreeding floaters.

The population of floaters on the Semidis increased markedly near the end of the season, whereas nonbreeding site holders behaved like failed birds in that they left the colony steadily through July and August. Moreover, numbers of nonbreeding site holders, and possibly also floaters, were higher before egg-laying than at any other stage of the season. A question that remains is whether the late-season influx of floaters included some of the same birds that were present in April and May or was made up of entirely new age groups. Extensive banding of known-age birds will be required to make that determination.

A comparison of attendance patterns in the colony I studied and fulmar colonies in the northeastern Atlantic reveals some notable differences. Fulmars at British colonies exhibit a strong attachment to their breeding sites throughout the greater part of the winter (Fisher 1952; Dott 1973), whereas fulmars appear to be absent from the Semidi Islands for about six months from October through March. The population in Britain has increased rapidly in recent years (Fisher 1952; Cramp et al. 1974), and the difference in attendance during the nonbreeding season at Pacific and eastern Atlantic colonies may be related to increased competition for breeding space in the expanding Atlantic population.

Coulson and Horobin (1972) found that attendance of fulmars at a small British colony underwent wide fluctuations in winter, but synchronized movements were not as clearly

TABLE 2. Effect on colony attendance by Northern Fulmars of wind speeds and directions on the day of the count and on the five preceding days.

Day	Wind speed[a]	n	Count[b]	Effect of strong wind	t	P<	Wind direction	n	Count[b]	Effect of north wind	t	P<
i	strong	278	19.6	−3.5	2.26	0.05	north	195	17.6	−5.9	3.45	0.001
	light	214	23.1				south	211	23.5			
i-1	strong	274	18.8	−5.5	4.72	0.001	north	192	16.0	−7.9	4.87	0.001
	light	212	24.3				south	208	23.9			
i-2	strong	268	18.8	6.0	4.01	0.001	north	188	17.5	5.3	3.12	0.01
	light	212	24.8				south	206	22.8			
i-3	strong	263	19.9	−3.9	2.54	0.05	north	185	19.2	−2.9	1.67	NS
	light	211	23.8				south	203	22.1			
i-4	strong	258	21.3	−0.1	0.63	NS	north	183	20.9	−1.1	0.58	NS
	light	210	22.2				south	199	22.0			
i-5	strong	255	22.0	+0.8	0.53	NS	north	180	21.8	+0.2	0.09	NS
	light	207	21.2				south	197	21.6			

[a] Strong wind > 10 knots; light wind ≤ 10 knots.

[b] Percentage of failed and nonbreeding site holders present.

defined as those observed at the Semidis in April and May. Although departures of all or most of the birds occurred on occasion in their study, there were also periods of two to three weeks when site occupancy remained at a relatively constant level. It was exceptional for more than 60% of the occupied sites to have pairs in the Atlantic colony, whereas 90% was typical on days of peak attendance at the Semidis. Those differences suggest longer or more synchronized foraging trips at the Semidis.

In the months preceding egg-laying, Coulson and Horobin (1972) observed a rapid build-up in numbers each morning and an abrupt decrease in the afternoon or evening, leaving the ledges completely deserted during the night. At another colony in Great Britain, Dott (1975) noted a daily cycle of activity featuring peak attendance in the forenoon after about mid-July. In the comparatively short pre-laying period at the Semidis, there was no counterpart to brief daytime attendance and night-time desertion, and peak attendance generally occurred in the evening rather than mid-morning. The meaning of those differences is unclear, but if fulmars tend to feed at night throughout their range, then the hour at which birds arrive at a colony during the day may depend on the distances travelled to and from the feeding grounds.

The strongest effect of weather on colony attendance at the Semidis pertained to wind direction, with northerly winds causing a decrease in the number of fulmars on land and southerly winds having the opposite effect. When the wind is blowing, fulmars use a method of flight known as slope soaring, in which ocean waves are the slopes (Pennycuick 1975). It is an energetically efficient method of travel that tends to carry the birds in a crosswind direction as well as downwind. A relatively strong effect of wind direction on colony attendance would be expected if fulmars have specific feeding grounds located at some fixed distance and bearing from a particular colony. Other studies have revealed no correlation between wind direction and colony attendance in fulmars (Coulson and Horobin 1972; Dott 1975), but Manikowski (1971) noted differences associated with wind direction in the number of fulmars and other seabirds observed at sea.

The depressing effect on colony attendance of either a strong wind or a northerly wind lasted about three days at the Semidis (Table 2). In contrast, Coulson and Horobin (1972) found that a strong wind depressed colony attendance on the day of the count and on the following day, but an increase in attendance occurred on the second day following a strong wind, irrespective of the wind speed at the time. They interpreted this as indicating the time it takes fulmars to return after leaving on a foraging trip. If that interpretation is correct, it again suggests that feeding trips lasted longer at the Semidis.

The mean effects of weather variables were too weak to explain variation in colony attendance in terms of simple linear relationships. An alternative view, supported by the autocorrelation analysis, is that regular cycles of presence and absence were endogenous. Specifically, the damped wave form of the autocorrelation functions in Figure 7 is expected of cycles (biological, as opposed to physical ones) that are prone to become progressively out of phase over time (Pielou 1974). However, conclusions about endogenous rhythm may be premature for series that encompass few repetitions of the purported cycle (Pielou 1974), and there was evidence that the mass arrivals and departures observed during the pre-laying period were indeed triggered by particular weather conditions (Table 1).

Thus, the correct interpretation may be that fulmars use certain cues in their environment, a change in wind direction for one, and possibly others unknown, to mediate behaviour patterns that primarily serve a social function. Synchronized attendance at the colony during the pre-laying period may be related to the acquisition and defence of breeding sites and mates, for it is otherwise difficult to account for the total desertion and re-occupation of the breeding area that occurs during that stage of the season. According to this view, once the birds have made a collective response to a particular set of weather conditions, the pattern of attendance for the next few days is set, largely irrespective of the weather.

Acknowledgments

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Population Fluctuations and Spatial Relationships among Wolves, *Canis lupus*, Coyotes, *Canis latrans*, and Red Foxes, *Vulpes vulpes*, in Jasper National Park, Alberta

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Coyote (*Canis latrans*) sightings in the Athabasca River valley of Jasper National Park, Alberta, increased from 0.13/d in 1980 to 0.91/d in 1984, and decreased to 0.07/d in 1988, coinciding with a fluctuation in the local Wolf (*Canis lupus* population. Observations of Coyotes and Red Foxes (*Vulpes vulpes*) suggested strong spatial segregation, with Coyotes predominant in prey-rich valley bottoms and foxes common only on mountainsides. It is hypothesized that foxes were unable to utilize valley bottoms because of Coyote presence.

Key Words: Coyote, *Canis latrans*, Wolf, *Canis lupus*, population fluctuations, Red Fox, *Vulpes vulpes*, spatial segregation, Jasper National Park, Alberta, interspecific competition.

Prior to the arrival of Europeans in present-day Jasper National Park (JNP) in the early 1800s, the only canids were probably Wolves (*Canis lupus*) and Red Foxes (*Vulpes vulpes*). I found no Coyotes (*Canis latrans*) mentioned in Hudson's Bay Company Post journals and fur records from western Alberta, 1800-1850. To my knowledge, the earliest records for the species from JNP are from 1895, as cited in Soper (1970). According to Banfield (1974) Coyotes expanded their range in North America during the 1800s and 1900s to the north and east. I believe that this range expansion followed local extirpation or scarcity of Wolves, and it is possible that Coyotes did not spread into the JNP region until the late 1800s when Wolves and their ungulate prey species were very scarce due mainly to over-hunting (Stelfox 1971).

In the 1900s, Wolf populations have fluctuated greatly in JNP in response to control measures and fluctuations in hoofed mammals (Carbyn 1974, Dekker 1985b). Coyotes are considered abundant especially in montane valley bottoms (Holroyd and VanTighem 1983). Although Red Foxes were numerous in 1914 on river flats near the north boundary of JNP (Soper 1970), local trappers Al Johnson and Bert Hanson find them now extremely scarce (Personal communication). In 22 years of hiking I found no evidence of foxes at Willow Creek in northern JNP, where wardens saw the species only at high elevations. Based on Warden Office files, Holroyd and VanTighem (1983: 333-334) conclude that Red Foxes are "very rare in JNP . . . and little is known about the life history of the species in boreal and mountain regions."

This paper reports sightings of Red Foxes and Coyotes in the lower Athabasca River valley in JNP during a period of fluctuating Wolf numbers, 1980-1989.

Study Area and Methods

The study area was roughly 20 km^2 at a base elevation of 1004 m in the Devona District of the Athabasca River valley of JNP (53°09′N 118°00′W) (Figure 1). The 2-2.5 km wide river valley bottom is quite flat and flanked by abruptly rising mountain ranges that are forested below the 2100 m level with White Spruce (*Picea glauca*) and Lodgepole Pine (*Pinus contorta*). Trembling Aspen (*Populus tremoloides*) and willow (*Salix* spp.) occur at lower elevations. The valley bottom contains montane meadows, and the lower mountain sides feature semi-open grasslands that allow good opportunities for viewing wildlife. The study area is a major wintering ground for Wapiti (*Cervus elaphus*) and Bighorn Sheep (*Ovis canadensis*). Mule Deer (*Odicoileus hemionus*), White-tailed Deer (*Odicoileus virginianus*), and Moose (*Alces alces*) are common. From 1973 to 1982, and again from 1984 to 1989, a Wolf pack of 8-14 animals used the area as a year-round hunting ground (Dekker 1985a, 1986). The climate of the area is continental with long, cold winters and heavy snowfall, but accumulations at Devona are usually light due to the moderating influence of chinook winds. Holroyd and VanTighem (1983) provide a detailed description of the area's climate, vegetation and fauna.

I visited the study area 3-13 times yearly between 1 October and 31 March, 1980-1989. Field trips varied from two to five days, but the first and last days of each visit were considered as half observation days, since I arrived in the valley

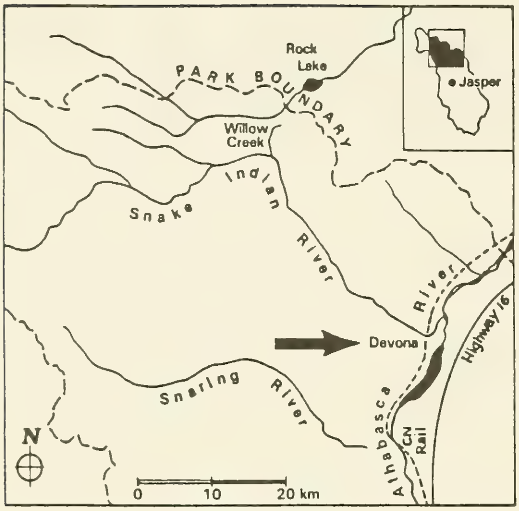

FIGURE 1. Map of study area location in Jasper National Park, Alberta.

TABLE 1. Sightings of Coyotes and Red Foxes at Devona, Jasper National Park, Alberta, 1 October-31 March 1980-1989.

Year	Observation days	Coyotes sighted	Foxes sighted
1980	8	1	1
1981	12	2	0
1982	18	6	2
1983	18	11	0
1984	11	10	0
1985	17	10	2
1986	25	4	1
1987	22	3	2
1988	29	2	13
1989	26	6	3
Totals	186	55	24

between 1100 and 1400 h, and I would depart on the last day of the visit in early afternoon. Thus, a three-day visit accounted for two full observation days. During each visit, I used the same camp site and hiked over the same ground. Sightings of Coyotes, foxes and other animals were recorded in note books. Tracks of Red Foxes, positively identified by narrow heel pad and other characteristics (Murie 1954, Dekker 1985c), were counted conservatively, assuming that several sets of similarly-sized tracks at one location were made by the same fox.

Results

Of 55 Coyotes sighted, 45 were single and 10 were in pairs. All Coyotes appeared well-furred and there was no evidence of disease. Numbers of Coyotes per day increased from 0.13 in 1980 to 0.61 in 1983 and 0.91 in 1984, and decreased again to a low of 0.07 in 1988 (Table 1).

Red foxes were seen on 24 occasions. All except four of the fox sightings were on or near the slopes. By contrast, 82% of Coyote sightings were on valley bottoms (Table 2). The recorded sightings show a significant difference ($P < 0.001$ Chi-square) in location between foxes and Coyotes.

Fox tracks were found whenever snow conditions were suitable along the mountainsides at Devona and adjacent slopes between Snaring and Miette cabin. From 1980 to 1987, 106 fox tracks were counted on the hillsides or near their base, and nine tracks led away from the slopes on to the valley bottom for more than 0.5 km. No count of Coyote tracks was kept, but they appeared to be ubiquitous on the flats and occasional on the slopes until 1986-1989, when Coyote tracks became far less common.

No Coyotes were sighted between February 1987 and October 1988. In the winters of 1987 and 1988 fox tracks were very common at Devona and found often on the valley bottom. As indicated by tracks and direct observation, these foxes were hunting small rodents on the grassy flats. All of four fox sightings on the valley bottom occurred in 1988. In October 1988, I found a dead fox on the river flats surrounded by tracks of wolves and a Coyote. Fox sightings peaked at 13/y in 1988, when at least five different individuals were seen, as recognized by colouration. Total sightings of all years included nine red phase, six silver or black phase, and nine intermediate or cross foxes. In 1989, 8 fox sightings were reported by naturalists and wardens along the valley escarpments within 12 km of Devona, and 4 foxes were seen in the Jasper townsite (personal communication, warden Wes Bradford and others).

Discussion

The reasons for the fluctuation in Coyote sightings are not clear, but the highest counts of 1983-1984 coincided with the disappearance of the locally denning Wolf pack (Dekker 1986) possibly as a result of control measures on adjacent provincial grazing leases. A pack of 6-9 Wolves

TABLE 2. Habitat location of Coyote and Red Fox sightings at Devona, Jasper National Park, Alberta, 1 October-31 March 1980-1989.

Habitat	Coyotes	Red Foxes
Semi-open valley bottom	45	4
Semi-open hillsides	10	20

again used the area as a home site and hunting range from the autumn of 1984 to the summer of 1989, when pack size dropped to five or less. Wolf populations in all of JNP declined in 1989 to a low estimate of 27-40 from maximum estimates of 80-100 in 1974-1976 (Dekker 1986).

Coyotes compete with Wolves for food resources and there is evidence from JNP and elsewhere that Wolves kill Coyotes (Carbyn 1982). Killing by Wolves was believed to be the cause of the elimination of Coyotes from Isle Royale (Mech 1966, Peterson 1977), where ingress of transient Coyotes is unlikely because the island is isolated from the mainland by at least 24 km of water. By contrast, interaction with Wolves did not result in the exclusion of Coyotes from Riding Mountain National Park, which is surrounded by agricultural lands where Coyotes are common (Carbyn 1982).

Even if Wolves remain common in JNP, Coyotes will probably not disappear because (1) they concentrate in areas of low Wolf occurrence, and (2) they disperse into the park from settled lands to the east Bowen (1981, 1982) found transient Coyotes common in the lower Athabasca River valley in JNP.

It is apparent that Red Foxes avoided the valley bottom in the study area, at least until 1987, but the reasons are not known. No detailed food analysis was done but cursory examination of winter scat in January to March, 1985-1986, revealed a high content of Bearberries (*Arctostaphylos uva-ursi*) which grow most commonly on open hillsides. Their arid condition and sparse vegetation probably make much of these slopes poor habitat for small rodents on which foxes and Coyotes feed. Some valley bottom habitats in the montane ecoregion of JNP have a high diversity and density of small mammalian prey species (Holroyd and VanTighem 1983). I hypothesize that these prey-rich valley bottom habitats are not available to foxes because of competition from Coyotes. Telemetry studies by Bowen (1982) found that Coyote home ranges completely occupied the Athabasca Valley below the 1200 m elevation contour, with the ranges of single Coyotes superimposed on those of packs and pairs. Voigt and Earle (1983) reported that fox families avoided Coyote territories in Ontario. Dekker (1983) observed spatial segregation and hostile interaction between foxes and Coyotes in central Alberta. In central Alberta and in JNP, I often found fox tracks on steep ravine banks and snow cornices. Precipitous, snow-covered terrain may be less hazardous for foxes than for larger canids because of the fox's lighter weight and relatively larger feet. In the study area, a fox that fled from a Wolf, ran to the hills. Another fox, that fled from me, ran up a near-perpendicular craggy river bank of 20-25 m in height. It is well-known that Bighorn Sheep seek out precipitous terrain to escape large canids. If foxes use a similar strategy, they might feel more secure in steep hills that in flat lands where Coyotes are common.

Further observation in the Athabasca River Valley should determine whether the distribution of Red Foxes and Coyotes will change. As of 1989, it has become evident that foxes have become far more common in JNP than before, at least on the hillsides of the lower Athabasca Valley, while Coyotes appear to have declined except around the townsite and along roads and railways where they scavenge on the carcasses of traffic-killed elk, sheep and deer.

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Nesting Biology of Pacific Loons, *Gavia pacifica*, on the Yukon-Kuskokwim Delta, Alaska

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The nesting biology of Pacific Loons, *Gavia pacifica*, was studied from 1973 to 1975 on the Yukon-Kuskokwim Delta, Alaska. Loons maintained territories on ponds throughout the pre-nesting period. Both adults incubated eggs and raised the young. Males incubated more than females during early incubation, and females more than males during late incubation. The female assumes much of the early brood rearing, with the male assisting more when food demands of young increase later in brood rearing.

Key Words: Pacific Loons, *Gavia pacifica*, nesting biology, brood rearing, Alaska.

The Pacific Loon, *Gavia pacifica*, commonly nests on the Yukon-Kuskokwim Delta, Alaska. As part of a study on the nesting ecology of Pacific Loons (Petersen 1979), I collected additional information on parental behavior in relation to feeding behavior of adults and young, as well as egg size within clutch in relation to laying sequence.

Study Area

A 12.3 km^2 study area (61°26′N, 165°26′W) was established on the Clarence Rhode National Wildlife Range (now the Yukon Delta National Wildlife Refuge) about 25 km from the Bering Sea coast. Habitats on the study area were predominantly wet marsh tundra and heath tundra similar to those described by Holmes and Black (1973). The study area contained 266 lacustrine ponds 0.2 to 100 ha ($\bar{X}$ = 1.5 ha) in size and averaged 1.5 m in depth (Petersen 1979). All ponds used by loons contained fishes. Ninespine Stickleback, *Pungitius pungitius*, was the only species found. Shore vegetation was primarily Burr Reed, *Sparganium* spp., Marsh Fivefinger, *Potentilla palustris,* Sedges, *Carex aquatilis* and *C. lyngbyei,* and Mare's Tail, *Hippuris vulgaris* and *H. tetraphylea.* Submergent plants in most ponds were Pondweeds, *Potamogeton filiformis* and *P. perfoliatus.*

Methods

I observed loons throughout the nesting season from three 5-m tall towers, from canvas blinds on the ground, and while walking through the area. Observation periods ranged from one to four hours and were concentrated on two pairs in spring 1975 (16 periods totalling 59.9 hours), three pairs during incubation in 1975 (7 periods totalling 26.4 hours), and three pairs during brood-rearing in 1973 and 1975 (30 sessions totalling 83.1 hours). No observation periods were conducted in 1974 as no eggs survived until hatch (Peterson 1979). Observations occurred during all daylight hours, but fog and rain precluded an equal distribution of observation times. I identified individual adults by differences in plumage (Lehtonen 1974) and determined the sex within pairs by copulation position.

During these observation periods, I recorded the amount of time adults foraged, the amount of time adults fed young, and the number of food items fed to young per feeding bout. A feeding bout was defined as a continuous period of foraging and feeding uninterrupted by other activities. The type of foods fed to young and eaten by adults was determined by observing where adults were obtaining food and by estimating the size and shape of prey in the bills of adults.

I measured the length, breadth, and weight of the eggs of 25 clutches of known laying sequence. To estimate the fresh weight of eggs not weighed before day 2 of incubation, I multiplied the volume, as calculated following Anderson et al. (1970), by the average specific gravity ($\bar{X}$ = 1.08, SE = 0.01, N = 26) that I measured for fresh Pacific Loon eggs.

Results

Role of adults

Pairs remained together on their nesting ponds during daylight hours from their arrival in spring through hatch (Table 1). At dusk, pairs flew toward the coast where there were believed to be open leads. The female began incubation immediately after laying the first egg and was the only bird observed on the nest during daylight hours until day 3. Thereafter, the male was

TABLE 1. Summary of presence and general activity of territorial pairs of Pacific Loons.

				Percent of total time when on territories spent:					
	No. hrs.	No. sessions	Percent of time present	Foraging	Sleep swim ?	Aggressive encounters (intra- and inter-specific)	Mutual displays	Other[1]	Incubating or brooding
Prenesting	59.9	20							
Male			100.0	40.2	48.5	8.2	3.2	-	NA
Female			100.0	58.2	30.4	8.2	3.2	-	NA
Early Incubation (day 1-14)	24.1	6							
Male			84.8	3.3	-	0.9	0.7	3.4	91.7
Female			49.8	85.8	7.4	-	0.1	3.1	3.6
Late Incubation (day 15-28)	2.3	1							
Male			-	-	-	-	-	-	-
Female			100.0	0	0	0	0	0	100.0
Early broodrearing (day 4-12)	13.0	4							
Male			30.5	0.4	99.6	0	0	0	0
Female			100.0	45.4	5.1	0.8	0	0	38.7
Late broodrearing (day 17-63)	71.1	26							
Male	0	0	84.9	20.0	76.2	3.2	0	0.6	0
Female	0	0	97.7	53.7	43.0	2.8	0	0.5	0

[1] Includes disturbance by airplane, disturbance by foxes, unknown disturbances and present but out of sight in pond.

predominantly on the nest during the day until about day 14. During the second half of incubation, only the female was on the nest during one observation period at that stage. After hatch, females primarily cared for the young until the young were about 18 days of age, after which both adults cared for the young.

Foods and feeding

Prior to egg-laying, the number of daylight hours spent feeding varied from day to day but totalled 40% for males and 58% for females (Table 1). During incubation, the non-incubating member of each pair was frequently on the pond during the daylight hours and foraged almost continuously. Immediately after the eggs hatched, females ate less frequently than during early incubation. Males ate infrequently when with the young (Table 1).

In spring, large numbers of dead Ninespine Sticklebacks were frozen in the ice of the ponds and were eaten by loons as they became available as the ice melted. Loons were observed eating sticklebacks from 12 to 72 mm in length. Fishes were occasionally seen in the bills of adults throughout the nesting season, but most items

TABLE 2. Egg sizes for 25 clutches of Pacific Loons from the Yukon-Kuskokwim Delta, Alaska.

	Length (mm) x ± S.E. (Range)	Breadth (mm) x̄ ± S.E. (Range)	Volume (ml) x̄ ± S.E. (Range)	Weight (g) x̄ ± S.E. (Range)
First egg	77.1 ± 1.7 (69.9 - 83.9)	48.5 ± 0.3 (46.4 - 51.5)	91 ± 1 (80 - 103)	98 ± 1 (86 - 111)
Second egg	76.2 ± 85.0) (70.0 - 85.0)	47.7 ± 0.3 (44.5 - 51.0)	87 ± 1 (74 - 104)	94 ± 1 (80 - 112)
P value[1]	N.S.	$P < 0.01$	$P < 0.001$	$P < 0.001$

[1] Paired *t*-tests between first and second eggs.

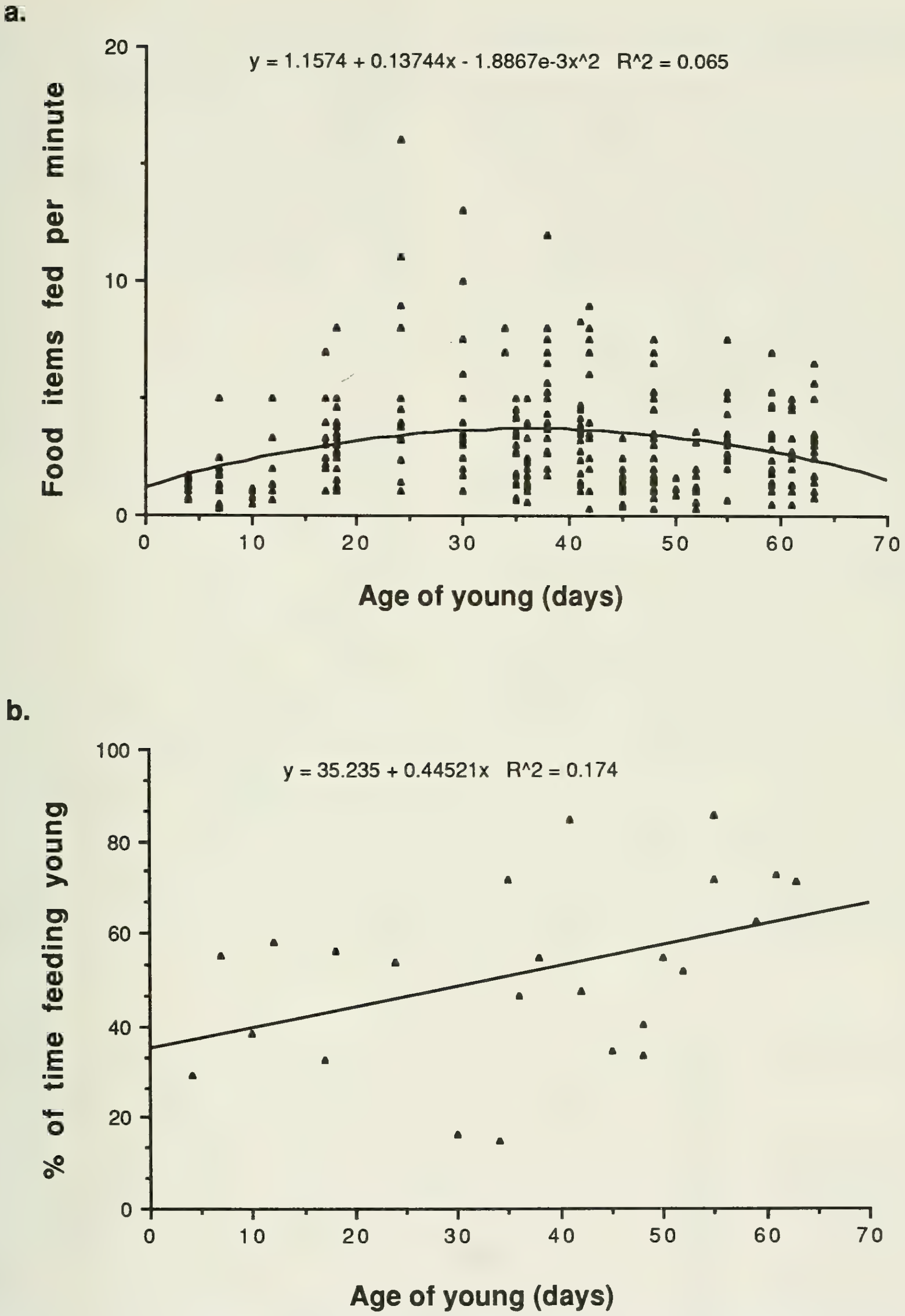

FIGURE 1. Average number of food items fed to young Pacific Loons per minute per feeding bout (a.) and the percent of time during daylight hours adults fed young (b.). Data points represent means for each pair for each day or for each feeding bout.

were unidentified. Adults foraged for insects and insect larvae by head-dipping in shore vegetation and for fishes by diving in open water. Adults fed small items (probably insects and insect larvae) to their young soon after hatch. Fishes (sticklebacks) as well as insects were fed to older young until fledging.

Broods

Young hatched asynchronously; the first egg laid (the larger) (Table 2) always hatched first. The second egg hatched one day later. Ten, one, and 10 young were raised on the area in 1973, 1974, and 1975, respectively. All but two young remained in the pond near their nest until fledging. The two that moved did so only to an adjacent similar sized pond when 21 or more days old.

Young were first led from the nest when they had reached one or two days of age and were brooded occasionally at various locations on shore until 12 days of age (39% of time observed). Young followed adults closely, when less than three weeks of age and especially when the adult foraged. Feeding activity was occasionally initiated by begging young. Begging was similar to that described for young Black-throated Loons, *Gavia arctica*, (Bundy 1979) and young Yellow-billed Loons, *G. adamsii,* (Sjölander and Ågren 1976). Young Pacific Loons begged by "nibbling" at the breast and flank feathers of adults when the adults were not foraging and after the adults made unsuccessful dives.

Adults fed young food items a greater percentage of the time with increasing age of their young ($F_{1,22} = 4.596$, $P < 0.05$) (Figure 1b). The number of food items per minute fed to young by females increased until the young reached 18 days of age ($F_{1,64} = 31.192$, $P < 0.001$). Feeding rates decreased slowly after the young were 24 days of age (Figure 1a). This change corresponded to a change from head-dip foraging (for insects and larvae) near shore, to diving near shore and throughout the pond for fishes. Fishes fed to young appeared larger the last month of the brood rearing period; this corresponded to the growth of sticklebacks through the summer. Different pairs fed food items to young at different rates; the change of feeding rate as young grew older was similar among all pairs. The increase in size of fishes fed to young loons with increasing age of young is also common with other loon species (Lehtonen 1970; Reimchen and Douglas 1984).

Young were observed flying from their nesting pond, circling the area, then landing in the nesting pond at 50 to 55 days of age. Young disappeared from brood rearing ponds between 57 and 64 days of age (1974, between 57 and 64 days; 1975, one each at 62 and 63 days) and were not seen again on the study area.

Discussion

Pacific Loons maintained territories on ponds throughout the pre-nesting period, both adults incubated eggs, and both adults raised young. In other loon species the male Red-throated Loons, *Gavia stellata*, spend less time feeding young than females and males engage in territorial activity more than females (Reimchen and Douglas 1985). Both members of the pair of Pacific Loons spent an equivalent amount of time on the territory and both defended equally. In contrast with observations of closely related Arctic Loons, *Gavia arctica*, (Lehtonen 1970; Sjölander 1968), my results indicate that female Pacific Loons incubated less than males during early incubation.

TABLE 3. Physiological condition of adult Pacific Loons.[1]

Date	Weight gm	Culmen mm	Fat %	Protein %	Water %	Comments
Males						
11 November 1975	2275	52.5	10.5	27.8	61.7	Wintering area[2]
31 December 1974	2320	55.4	25.9	24.1	50.0	Wintering area[2]
30 May 1974	2350	62.0	17.0	19.3	54.7	Late spring
01 June 1974	2500	56.0	17.5	24.4	55.7	Late spring
31 August 1973	1990	56.9	-[3]	-	-	Late brood rearing
Females						
10 December 1974	2170	52.0	30.5	22.4	47.1	Wintering area[2]
25 May 1974	2320	51.5	-	-	-	Mid-spring
12 June 1975	1670	52.1	5.5	30.4	64.1	Day 3 of incubation
30 June 1974	1810	50.8	8.5	28.2	63.3	Hatching
10 August 1973	1840	55.0	-	-	-	Mid-brood rearing

[1] See Raveling (1979) for a complete description of proximate analysis technique and calculations.
[2] Monterey Bay, California.
[3] Data not collected.

Since females lay two relatively large eggs (about 10% of their weight at the beginning of incubation), they expend significantly more energy (both fat and protein, Table 3) than males before incubation. Males should be in better condition than females at the beginning of incubation, and by males assuming the bulk of early incubation duties, they allow the females to rebuild their reserves. The female assumes much of the late incubation (based on only one observation period) and the early brood rearing, while the male has the opportunity to rebuild fat reserves lost during extended incubation. The male assists with feeding when demands of young increase later in brood rearing.

Acknowledgements

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Breeding Ecology of the Sora, *Porzana carolina*, and the Virginia Rail, *Rallus limicola*

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The breeding behavior of Soras (*Porzana carolina*) and Virginia Rails (*Rallus limicola*) was observed under captive and field conditions, in Iowa and Minnesota during the 1963-69 field seasons. Territorial defense was accomplished primarily by males. The Soras' territories were well-defined and defended against both species; the Virginia Rails' territories were less defined and defended mainly against other Virginia Rails. Pair formation of both species appeared to be subtle; potential mates stood immobile near each other for increasing lengths of time and decreasing distances between them. Females of both species appeared to select the nest site on the day they laid their first egg. Clutch sizes of Soras were larger than those of Virginia Rails. Incubation was usually initiated before the clutch was completed in both species, particularly in the Sora, and so the young hatched asynchronously. In both species the males and females incubated the eggs, brought food to the young, and brooded the young, but the relative role of the sexes varied from pair to pair. In most pairs, the females of both species performed the majority of incubation and brooding, whereas the majority of the food was brought by male Soras and female Virginia Rails. I suggest that interspecific competition exists between the two species as a result of the Sora's inefficiency in gathering invertebrate food for the young. The Sora appeared to have evolved a number of morphological and behavioral mechanisms to ensure an adequate supply of food for the young. These include defense of their territory against all rail species, the evolution of conspicuous facial coloration to reinforce threat displays, prolonging the period of chick feeding by staggering the hatching period, and feeding only the younger chicks, possessing conspicuous coloration.

Key Words: Sora, *Porzana carolina,* Virginia Rail, *Rallus limicola,* territory, hatching asynchrony, sexual roles in incubation and brooding, interspecific competition.

Soras (*Porzana carolina*) and Virginia Rails (*Rallus limicola*) are among the most common inhabitants of inland marshes of North America, but their secretive nature has restricted our observation. Their lack of sexual dimorphism makes it very difficult to determine the roles of the sexes in pair bonding, territorial defense, and raising of the young. Both species nest in the same marshes and respond to each other's calls, but the degree of interspecific competition has not been well documented. The two species do not exhibit partitioning of the marsh habitat (Johnson and Dinsmore 1986) but do exhibit partitioning of their foods (Horak 1970).

My study combined observations in the field with those of penned birds nesting in simulated marsh conditions. I sought to describe their basic breeding behavior, and compare their adaptations to the marsh environment.

Study Areas and Methods

Study sites included Elk Creek Marsh, Worth County, Iowa, in 1963-65; the backwaters of the Mississippi River at Mud Lake, Dubuque County, Iowa, Green Island Marsh, Jackson County, Iowa, and the Ruthven Game Management Unit, Clay County, Iowa, in 1965-66; and Cedar Creek Natural History Area and adjoining private marshes of Anoka County, Minnesota, in 1967-69. Field observations were carried out on a full-time basis during the 1963-66 breeding seasons, and part-time during the 1967-69 breeding seasons. Arriving and migrating rails were observed from blinds, flush counts, and drives into mist nets. Marshes were systematically searched for nests; nests were checked on a regular basis.

Nests of 49 pairs of Soras and 36 pairs of Virginia Rails were found in the wild. Blinds were built at 12 of these nest sites, and 6 Sora, and 7 Virginia Rail nests were observed. The adults were nest trapped, color marked, released, and observed in the wild for a total of 149 h. Seven Soras and ten Virginia Rails were captured as juveniles in 1966 and placed in an outdoor flight pen at Cedar Creek Natural History Area during the 1967-69 breeding seasons (Kaufmann 1977). The captive rails were observed full time during the 1967-68 seasons and part-time during the 1969 breeding season for a total of 645 h. During these seasons, 5 pairs of captive Soras formed pair bonds and defended territories, and 3 pairs nested; 5 pairs of captive Virginia Rails formed pair bonds, 3 pairs defended territories, and 1 pair nested. Observations of these captives provided most of my information on social behavior; their displays and vocalizations are described elsewhere (Kaufmann 1983). Time lapse photography, using a Super 8 camera, recorded the complete incubation of one pair of Soras.

Results

Spring Migration and Arrival: Migrants of both species arrived in Iowa and Minnesota during the last week of April and the first week of May, when temperatures rarely dropped below -1°C. In mid-May 1966, a three-inch snow fell at Ruthven, Iowa, and rails became so lethargic that they were captured easily by hand (L. Fredrickson and K. Hansen, personal communication). Although migrating rails of both species frequently called, they seldom called during their first week after arrival on the breeding grounds.

Territorial Behavior: The distribution of rail calls indicated that they were evenly dispersed in the marshes. Vocalizations in both species consisted primarily of the descending call; Soras also gave the per-weep (Kaufmann 1983). Descending calls were closely associated with hostile interactions in captive rails of both species, frequently given before and after chasing and during aggressive displays. Calls of territorial males were usually answered immediately by other territorial males of both species. Descending calls may also function in pair contact, for one member of the pair usually called soon after its mate began calling.

Calling of captive pairs remained at a relatively high rate from the time of egg-laying until several weeks after hatching. Periods of intense calling usually coincided with peaks in chasing activity (Figures 1 and 2). The rate of calling seemed to be affected by the density of breeding pairs. In a small marsh of approximately 12 ha on the Elk Creek Marsh area in Worth County, Iowa, 5 Sora nests were located after very intensive searching in 1963. Fifteen Sora nests were located in the same marsh in 1965 with much less effort. In 1963 fewer than 1 descending call/h was given during the incubation period. In 1965 more than 1 call/min was heard on several visits during the week when most birds were incubating.

Three pairs of successfully breeding captive Soras had territories of 45 to 55 m² in the breeding pen. A captive Virginia Rail pair had a maximum area of 76.5 m². These territories were probably smaller than those of wild birds. Nests of wild rails were scattered evenly in the marsh, and the highest density reported to date was 4 Sora and 5 Virginia Rail nests in 2023 m² (Berger 1951). However, active nests have been found as close as 3 m apart for Soras (Pospichal and Marshall 1954) and 4.5 m apart for a Sora and a Virginia Rail nest (R. S. Billard, 1947. An ecological study of the Virginia Rail *(Rallus limicola)* and Sora *(Porzana carolina)* in some Connecticut swamps. Unpublished M.S. thesis, Iowa State University, Ames, Iowa.)

Chasing appeared to be the most important method of establishing and maintaining a territory in captive rails. Males began by occupying a particular area of the pen and chasing all other rails from it. Continued defense of the area seemed to depend on subsequent pair-formation, at least in Soras. One very aggressive male Sora defended most of the area of the pen for over a week. He attacked all rails that approached him, even female Soras whose approach indicated an interest in pair formation. He was then defeated by a pair of Soras. Another male Sora defended an area of the pen but failed to maintain his territory. Subsequently, he formed a pair bond and then reclaimed his territory. Chasing occurred throughout the daylight hours, and some chasing even occurred at night. Most of the nocturnal chasing by captive birds resulted when other rails attempted to escape from the pen. Birds flew into the wire, and fell into the territory of another rail.

Captive males of both species chased more frequently than the females. In 5 pairs of captive Soras, the males performed 73% (N = 2151) of the chases. In 5 pairs of captive Virginia Rails, the males performed 71% (N = 975) of the chases. In addition, the males of both species usually chased 0.5 to 1 m further than the females. Male Soras directed slightly more of their chases (29%, N = 1599) toward other male Soras than against female Soras (26%), male Virginia Rails (27%), or female Virginia Rails (19%). Male Virginia Rails directed more of their chases against other male Virginia Rails (44%, N = 689) than against female Virginia Rails (41%), male Soras (7%), or female Soras (8%).

After the captive Soras established a territory, Virginia Rails continued to trespass but other Soras rarely did so. As a result of the continued trespassing by Virginia Rails, the 5 captive Sora pairs chased Virginia Rails nearly as frequently (47% vs. 53%, N = 2151) as they chased Soras, and the 3 male Soras, which successfully nested, chased Virginia Rails (70%, N = 1580) more than they chased Soras. Soras would come to the territorial boundary and perform Swanning with the opposing male, usually other Soras (83% of 384 Swannings). Other Soras, particularly males, would come to the territorial boundary and perform Swanning with the territorial male. Thus, chasing by male Soras was the primary means of interspecific defense, with Swanning in addition to chasing important in intraspecific defense. Female Soras rarely performed aggressive displays; the few observed were directed against other female Soras.

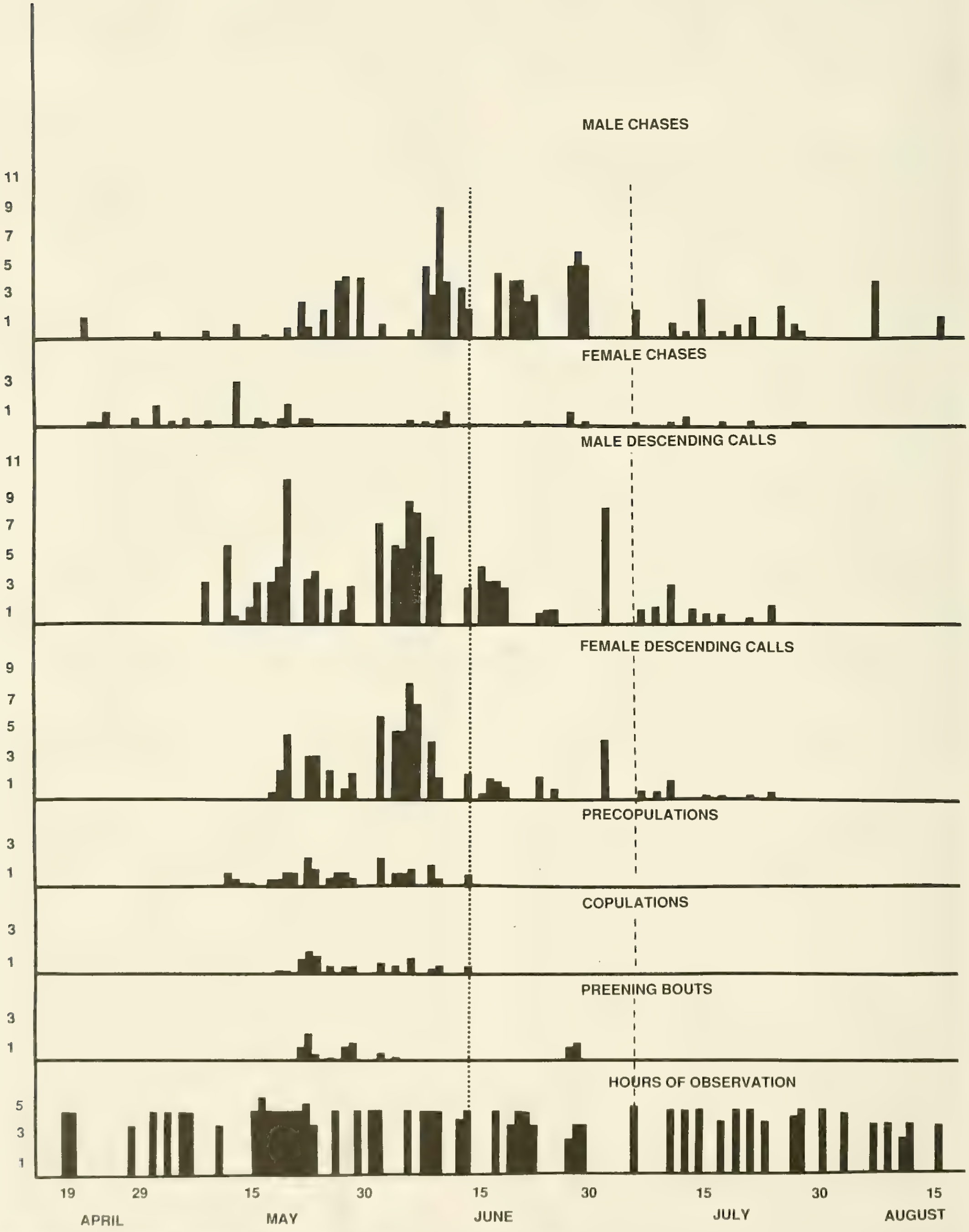

FIGURE 1. Seasonal distribution of territorial and courtship activities of Virginia Rail pair No. 1. Activities are graphed on a per hour basis; the dotted line indicates the date the first egg was laid, the dashed line indicates the date the first egg hatched. The female moulted her flight feathers 23 July, the male moulted his flight feathers 3 August.

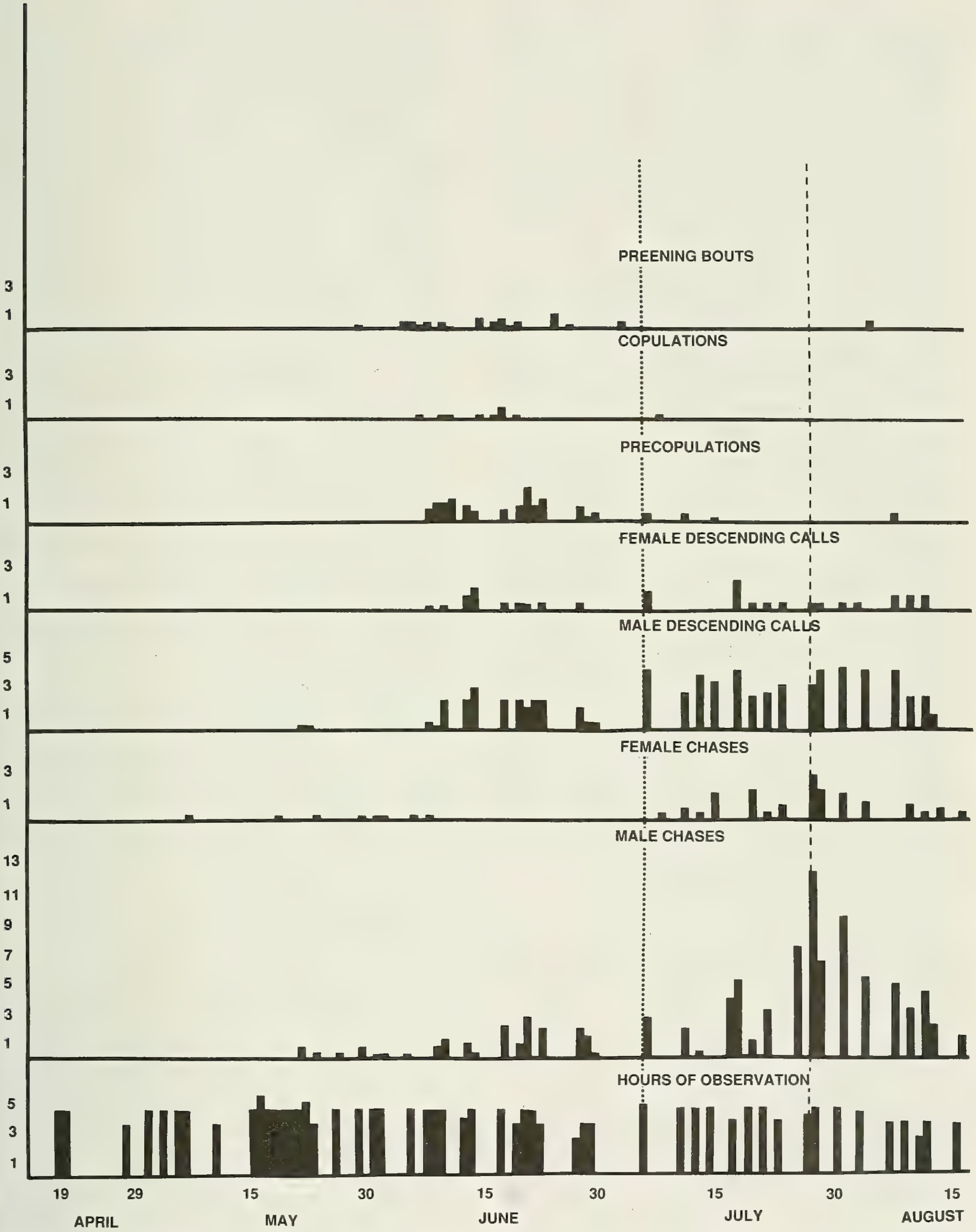

FIGURE 2. Seasonal distribution of territorial and courtship activities of Sora pair No. 5. Activities are graphed on a per hour basis; the dotted line indicates the date the first egg was laid, the dashed line indicates the date the first egg hatched. The female moulted her flight feathers 7 August, the male moulted his flight feathers 9 August.

In contrast, Virginia Rails defended their territories more vigorously against their own species than against Soras. Most of the chases (86%, N = 975) by the 5 captive pairs of Virginia Rails were directed toward their own species, and the pair which nested successfully directed 79% (N = 423) of their chases toward their own species. This is especially striking because this male encountered Soras more frequently than Virginia Rails. This male directed most (84%, N = 71) of his aggressive displays toward Soras.

Captive pairs which successfully nested began chasing 3 to 9 weeks before nesting (Figures 1 and 2). The rate of chasing greatly increased at about the time of egg laying and remained at high levels until hatching in the Virginia Rail pair and several weeks after hatching in the 3 Sora pairs. The frequency and intensity of chasing by all rails diminished as they became flightless.

The major peak of chasing activity for 2 Sora pairs was near the time of hatching, but chasing activity by a third pair peaked just before the laying of the first egg. Chasing probably would have peaked around hatching time for that pair and the Virginia Rail pair, as suggested by their increased rate of calling, had adjacent pairs been at the same breeding stage. The Virginia Rail pair lacked a definite peak of chasing; this pair chased less as the season progressed, at the same time that a Sora pair was encroaching on their territory.

Actual fighting was observed between 2 Sora males which had adjacent territories and synchronized breeding cycles. The first fights began about 3 weeks before egg-laying and continued for over a month after hatching. Attacks were most frequent during the egg-hatching period, when one male performed 30% (N = 30) and the other 60% (N = 35) of the attacks.

Pair formation and the pair bond: Five pairs of captive Soras and five pairs of captive Virginia Rails formed pair bonds. In some pairs the male took the initiative in approaching the potential mate; in other pairs, the female took the initiative. The two birds then quietly stood side by side for several minutes or for as long as 0.5 h. This activity, which I called "Mates Together", lasted for 1 to 2 weeks. After this period they became more active when near each other, spending more time feeding and bathing than standing in one place.

As the pair bond formed, the members of a pair engaged in bouts of allo- and autopreening, precopulatory chases, copulations, exchanges of calls, and mutual defense of their territory. Virginia Rails performed courtship feeding, but Soras did not. The male carried food 1-5 m to the female 13 times during the two weeks prior to egg laying. Courtship feeding actually occurred more frequently, but when the pair fed close together, it was impossible to distinguish courtship feeding from feeding on the same food item or underwater bill nibbling. Most courtship activities appeared about the same time, and no single activity was regularly the first to be observed (Figures 1 and 2).

In the period before incubation, most meetings between members of Sora pairs resulted in pre-copulatory chases (63%, N = 422) or preening bouts (24%). A few preening bouts (4%) were followed by pre-copulatory chases, and some pre-copulatory chases (8%) ended in preening bouts instead of copulation. Meetings of members of Virginia Rail pairs usually resulted in either preening bouts, pre-copulatory chases, or courtship feeding, after which the mates separated.

The first copulations of the Sora pairs were 40, 35, and 18 days before the first egg was laid. All three pairs ceased copulating 1 or 2 days before the last egg was laid, but one pair resumed copulation and engaged in bouts of preening a number of times after their young chicks drowned. The Virginia Rail pair was first observed copulating 20 days before the first egg was laid and ceased after the last egg was laid.

Reverse mounting was observed only in one Sora pair. The male presented himself to the female six times after their young had hatched. The female completely mounted him once, but no cloacal contact was made.

Nest Sites and Nest Construction: The majority of Sora nests (78%, N = 49) and Virginia Rail nests (70%, N = 37) were found in robust emergent vegetation, usually cattail (*Typha* spp.), the most common species available. I only recorded the dominant species of nesting vegetation throughout the study. By the end of the study I suspected that both species actually preferred a mixture of robust and fine vegetation, e.g., cattail with an understory of sedge (*Carex* spp.), but this was not recorded.

Females of the three captive Sora pairs and the captive Virginia Rail pair selected the nest site. In each case, nest-building began with the laying of the first egg; the female sat among the cattails and scraped a crude bowl for about 2 h, laying an egg in it during that time. Prior to the laying of the first egg, none of the successfully breeding pairs gave any indication that they had selected a nest site. During the week before nesting the Virginia Rail pair constantly and hurriedly walked about the pen squawking, apparently searching for a suitable site. The members of a second Virginia Rail pair also hurried about the pen for about a week before the male constructed a well-formed bowl in the place where he often rested and called. However, this pair was thoroughly beaten by the first pair the next day and no eggs were laid.

Nest construction was similar in the Sora and Virginia Rail, and the nests could be distinguished only by the eggs. The captive males gathered pieces of cattail and sedge and gave them to their mates, who worked them into the nest as egg-laying proceeded. The nest bowl and ramp were completed in about a week. The canopy was built by bending over the surrounding vegetation and tucking it into the rim of the opposite side. New vegetation which grew during the incubation period was also used for the canopy. Disturbances increased canopy building, particularly in the wild rails I observed. If I cut the canopy for observation, it was usually fully repaired soon after the incubating bird returned. Nests damaged by nest traps were also repaired. In one case, a nest trap failed to close, and the Virginia Rails carried a number of pieces of sedge and cattail, up to 0.5 m long, into the trap.

Egg-laying: Wild Soras and Virginia Rails usually laid an egg a day. In the pen, eggs appeared to be laid in mid-morning between 0800 and 1000 h. Captive Soras occasionally skipped days between laying eggs. One pair skipped a day twice, laying 8 eggs in 10 days; a second pair skipped a day four times, laying 5 eggs in 9 days; and the third pair skipped a day twice, and skipped 3 days once, laying 6 eggs in 11 days. Their clutch sizes were below the average of the species. Wild Soras have a larger clutch size than Virginia Rails. Clutch size data suggest an average of 10.5 eggs (maximum 16 eggs) in 165 Sora nests, and an average of 8.5 eggs (maximum 13 eggs) in 115 Virginia Rail nests (Table 1). These figures are probably underestimated, particularly for the Sora, because of possible loss of eggs through predation, as well as the possibility that a partially hatched clutch was mistaken for a full clutch.

Incubation: The asynchrony of hatching eggs indicated that the Soras began full-time incubation between the laying of the second egg and the eighth egg, whereas Virginia Rails began incubation 1-5 days before the laying of the last egg (Table 2). The three captive pairs of Soras began part-time incubation after the laying of the first egg, and engaged in full-time incubation three days after the first egg was laid. At the start of incubation both sexes sat on the eggs for short periods of time, interspersed with periods when the eggs were left unattended (Figure 3).

Incubation was shared by both sexes in both species (Table 3). In two Sora pairs the mates shared diurnal incubation about equally, but the female incubated about 60% of the time in a third pair. The females in four pairs of Virginia Rails incubated 60% to 80% of the time.

The bouts of diurnal incubation were longer, on the average, for the females of both species. The mean length of complete incubation bouts observed was 48.4 min for male Soras (110 bouts), 67.7 min for female Soras (106 bouts), 71.3 min for male Virginia Rails (13 bouts), and 119.7 min for female Virginia Rails (10 bouts). The calculations of complete bouts did not include the longest bouts of Virginia Rails which lasted over 3 h. The captive Virginia Rail pair appeared to have a fairly stable daily rhythm of incubation. The female was incubating on 10 occasions when I arrived before dawn. During the day, the birds changed over about every 1.5 h to 2 h. On three evenings, the male incubated for the last 3-4 hours before darkness. The female fed vigorously and almost constantly until near darkness, when she returned

TABLE 1. Clutch sizes of wild Soras and Virginia Rails.

Source	Range	Mean	No. Nests
Sora			
Walkinshaw (1940)	6-13	9.4	39
Billard (1947)*	8-15	11.8	9
Tanner and Hendrickson (1954)	?	10.0	24
Pospichal and Marshall (1954)	6-14	9.9	29
Lowther (1977)	9-16	12.2	32
Present Study	7-14	10.5	32
	6-16	10.5	165
Virginia Rail			
Walkinshaw (1937)	6-13	8.6	38
Billard (1947)	7-11	9.3	15
Tanner and Hendrickson (1954)	4-10	8.1	28
Pospichal and Marshall (1954)	4-11	7.5	8
Present Study	7-10	8.5	26
	4-13	8.5	115

*Billard, R. S. 1947. An ecological study of the Virginia Rail (*Rallus limicola*) and Sora (*Porzana carolina*) in some Connecticut swamps. Unpublished M.S. thesis, Iowa State University, Ames, Iowa.

TABLE 2. Span of hatching (days) of wild Soras and Virginia Rails.

Source	Range	Mean	No. Nests
Sora			
Billard (1947)*	5-17	10.5	8
Pospichal and Marshall (1954)	3-13	7.4	22
Present Study	1-10	3.4	5
	1-17	7.5	35
Virginia Rail			
Billard (1947)	1	1.0	6
Pospichal and Marshall (1954)	2-5	3.3	10
Present Study	1-2	1.1	7
	1-5	2.0	23

*Billard, R. S. 1947. An ecological study of the Virginia Rail (*Rallus limicola*) and Sora (*Porzana carolina*) in some Connecticut swamps. Unpublished M.S. thesis, Iowa State University, Ames, Iowa.

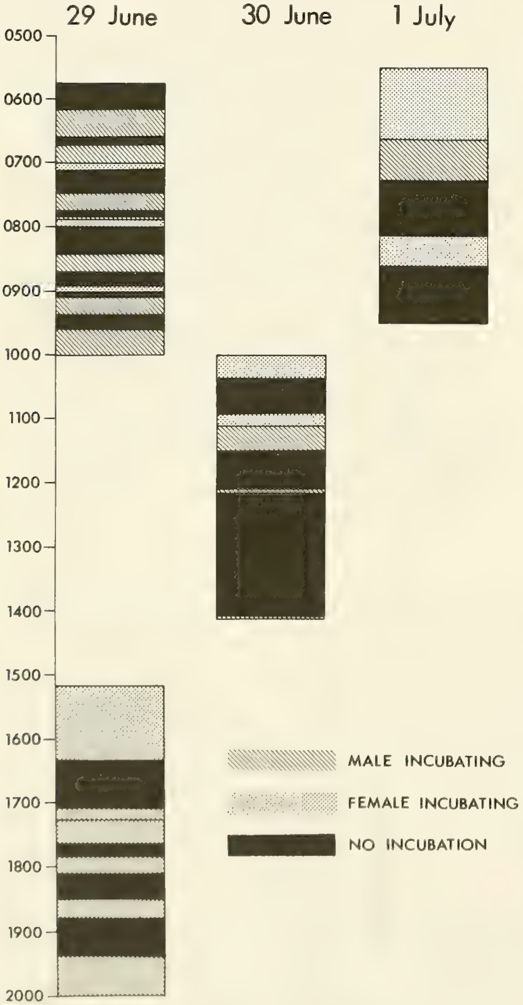

FIGURE 3. The initiation of incubation by a pair of Soras; the first egg was laid 28 June and full-time incubation began 2 July. Blank areas indicate no observation taken.

to the nest and incubated. During one 24-h observation period, the female incubated continuously from 22:35 to 09:07. Observations at the nest of a wild, color-marked pair of Virginia Rails produced different results. The male was incubating during one nocturnal check, and during three dawn checks the male was incubating twice. In five all-night observations of Soras the males initiated the incubation in four cases and a change over occurred each night.

In 1967, both pairs of captive Soras consistently gave a slow, constant gargle call before all nest exchanges. However, this call was not heard from the nesting pair in 1968. No calls or display movements were recorded at the time of change-over at Virginia Rail nests. Frequently the incubating bird left a minute or two before the mate arrived or as the mate approached. As the incubation period progressed, the incubating bird was more reluctant to leave the nest, and occasionally the returning bird pushed its mate off the nest.

Egg-Carrying: Disturbances may cause Virginia Rails to remove their eggs from the nest and possibly pierce them. I observed one male carry the eggs from the nest with his bill and lay them on the ground. This male and his mate were nest-trapped, and placed in a cage with the entire hummock containing the nest. Later that day he removed the eggs. I presumed another male removed his eggs from the nest and pierced some of them. The size and shape of the small holes suggested they had been pierced by a long bill, but had not been eaten. This male was trapped, banded, feather-dyed, and toe-clipped the previous day. I found eggs scattered about 35 m from a third Virginia Rail nest which I had not disturbed.

Carrying of eggs in the bill has been observed in several other species of *Rallus* and is probably the main method by which broken or rotten eggs are removed from the nest and displaced eggs retrieved

TABLE 3. Role of the sexes in diurnal incubation and brooding by Soras and Virginia Rails.

	Time (min.) Spent by Male		Time (min.) Spent by Female	
	Incubating	Brooding	Incubating	Brooding
Sora Pair No.				
1*	—	393	—	142
4**	1232	642	1000	828
5**	1188	481	1156	668
8**	4706	884	7412	1172
	7126	2400	9568	2810
	(43%)	(45%)	(57%)	(54%)
Virginia Rail Pair No.				
1*	1539	676	2457	688
4*	—	24	—	206
9*	48	60	212	77
36*	65	—	195	—
40*	134	423	193	1083
	1786	1183	3056	2054
	(37%)	(36%)	(63%)	(64%)

*wild birds — observed during the latter half of their incubation.
**captive birds — observed throughout incubation: Sora pair no. 8 was continuously recorded by time-lapse camera from the first full day of incubation.

(Turner 1924; Pettingill 1938; Percy 1951). However, egg-carrying has not been recorded in the shorter-billed species such as the Sora.

Hatching: The period between the hatching of the first and last egg was considerably longer in Soras than in Virginia Rails (Table 2 and Figure 4). Wild Soras initiated incubation any time from the laying of the first egg to the laying of the eighth egg. Soras with larger clutches initiated incubation earlier than those with smaller clutches and had a greater hatching span (Table 4).

Virginia Rails usually initiated incubation with the third last or the penultimate egg so that usually all but one or two of the eggs hatched on the same day, the last eggs hatching a day or two later.

Captive Soras began full-time incubation three or four days after the first egg was laid, and hatching of the four clutches was spread over 2, 3, 6, and 7 days. The hatching period was lengthened by the slower rate of egg-laying but reduced by the smaller clutch size as compared to wild Soras.

Eggshells of the first hatching eggs of both species were usually carried 1 to 3 m from the nest and dropped, whereas eggshells of the later-hatching eggs were frequently pecked into fragments in the nest and partly eaten. Tiny fragments of eggshells were found buried in the lining of all nests that hatched successfully.

Care of Young: Males of both species built a brood nest 2-3 days after hatching, and continued to add pieces of cattail at infrequent intervals for over two weeks. The three captive male Soras built brood nests 1.25, 3, and 4 m from their incubation nests, but the fourth male, whose young drowned, did not make a brood nest. The Virginia Rail male built a brood nest about 1.5 m from the nest. One

TABLE 4. Relationship between hatching span and clutch size in Soras. Data from Billard (1947)*, Pospichal and Marshall (1954), and present study.

Hatching Span in Days	Clutch Size								
	7	8	9	10	11	12	13	14	15
1									
2	1	1							
3									
4									
5					1	1			
6									
7								1	
8									
9						1			
10						1		1	
11									
12				1		1	1		
13							1		
14									
15									
16									
17									1

*Billard, R. S. 1947. An ecological study of the Virginia Rail (*Rallus limicola*) and Sora (*Porzana carolina*) in some Connecticut swamps. Unpublished M.S. thesis, Iowa State University, Ames, Iowa.

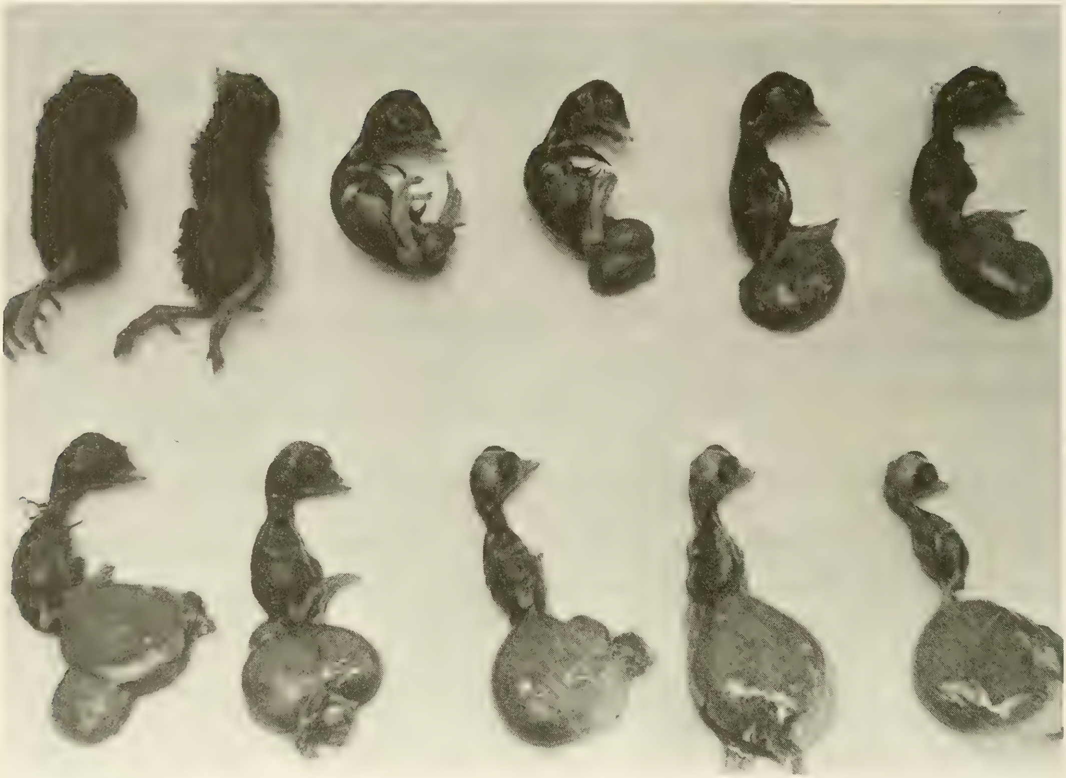

FIGURE 4. Chicks and embryos taken from a wild Sora nest the day the first chicks hatched. Full-time incubation began after the second egg and the clutch probably would have hatched over an 8-day span.

or two "dummy nests" were found near successful nests of both species in the wild and probably were utilized for brooding.

Diurnal brooding was shared by both sexes in a manner similar to incubation (Table 3). The chicks were constantly brooded by one of the parents for the first 4 to 7 days. Diurnal brooding decreased over the following two weeks, but nocturnal brooding continued longer.

Two or three days after hatching, rail chicks began to follow the adults from the nest. At first, the chicks moved less than a meter and then returned. After a few days they left the nest, feeding on their own, occasionally following an adult and begging. In these situations, the adult fed the chicks and brooded them on the brood nest, breaking off from time to time to carry food to the mate on the nest. Both sexes used both nests, but the males appeared to utilize the brood nest more than the females. When all of the chicks left the nest, they did not follow either adult closely, but scattered within the territory, occasionally going to either adult for feeding or brooding. The adults did not call to their young, but rather the young seemed to recognize the territory and searched for an adult within this area when they appeared hungry or cold.

Two wild families of Virginia Rails remained in their territories for 17 and 20 days after hatching; a third family was captured in its territory 12 days after hatching, and a fourth family abandoned its territory as soon as the last egg hatched. However, I had disturbed this last nest much more than the others during the incubation period. There was evidence of early movement of families in the absence of human disturbance. Two Virginia Rail families with young less than a week old crossed roads, and a third family was found run over by vehicles on a road.

When an adult Virginia Rail brought food to the nest, it was usually passed to the brooding bird, which in turn presented it to a chick. The young chicks frequently dropped the food item, and the brooding adult picked it up and presented it repeatedly, often crushing the item in the bill. As the chicks grew older, they ran out from under the brooding bird to take the food from the approaching parent.

At the change-over during brooding, the captive Virginia Rail pair passed the food item back and forth, sometimes over 100 times, between the members of the pair. This behavior gradually disappeared as soon as the chicks became more expert at taking food from the adults' bills. Repeated food passing between members of Sora pairs was not observed.

The role of the sexes in bringing food to the nest varied greatly in both species. Sora males made 26 to 64% of the food trips and male Virginia Rails made 28 to 65% of the food trips (Table 5).

Young Soras were fed by their parents for two to three weeks. During this time, the chicks gradually lost the orange beard, red cere and black down. When these older young begged to the parents for food, they were attacked by the males. Two captive males began to attack their offspring of 8 and 13 days of age. These attacks consisted of pecks and feather-pulling, but no serious injury was inflicted on the young. Thus, the older chicks increasingly avoided their parents. The adult males continued to feed the youngest of the brood. Both parents brooded all their young at night for at least several weeks after these attacks began.

The captive Virginia Rail pair fed their young slightly longer than the Soras, at least for 23 d. The first hostile interaction between the male and young was observed 29 d after hatching; the male displayed aggressively to one of his offspring; he was not observed chasing the young until they were 59 d old.

The chicks of both species were preened frequently by the brooding parent. Preening by the parent Soras increased when the young were hungry and frequently pecked at the parent's bill or peeped. Sometimes, the adult Sora appeared to prod or poke the young bird with its bill rather than preen it. Occasionally, a parent Sora vigorously poked at a chick, forcing it from the rim into the nest bowl. Brooding parents of both species ate the feces of the chicks.

The down of the chicks became waterlogged after a few minutes of swimming, particularly for the first few days after hatching. The chicks then peeped plaintively. One captive and one wild female Virginia Rail picked up their wet chicks with the bill by grasping their head or nape, and carried them back to the nest or to a raft of vegetation. The females then brooded them for 5 to 10 min. Other species of *Rallus* carry their young (Turner 1924; Johnson 1950; Percy 1951).

Apparently adult Soras do not carry their young. Several young captive Soras drowned in the water in front of the nest, and although the young could be seen and heard by the brooding parent the latter made no attempt to rescue the young. The ramps at the nests of the captive birds did not lead down to the water as in the wild rails, but stopped at the edge of the trough containing the cattails, about 10 cm above water level (*see* Kaufmann 1977 for pen description). Once in the water the young chicks were unable to climb up the wooden trough to get back into the nest. Neither drowning nor rescuing of Sora chicks was observed in the wild.

Discussion

Most bird species defend territories against conspecific individuals but some also defend territories against other, usually closely related, species (Orians and Willson 1964). The occurrence of such interspecific territoriality is believed to be uncommon, as it would require a tremendous

TABLE 5. The proportion of food brought to the nest by male and female Soras and Virginia Rails.

	Males		Females	
	No. Food Trips To Nest	% of Total Food Trips	No. Food Trips To Nest	% of Total Food Trips
Sora Pair No.				
1*	16	26	45	74
4**	200	63	119	37
5**	174	64	98	36
8**	23	45	28	55
	413	58	290	41
Virginia Rail Pair No.				
1**	59	28	150	72
4*	2	29	5	71
9*	21	48	23	52
40*	136	65	74	35
	218	46	252	54

*wild birds.
**captive birds.

expenditure of time and energy for a bird to defend its territory against all other birds. Interspecific territoriality among birds is most common in habitats where the major food source is located at the ground-air or air-water interfaces, permitting only a limited number of methods of exploitation. Prairie and marshland habitats thus have a greater incidence of interspecific territoriality compared with forests, which provide a much greater vertical stratification for feeding and breeding.

My observations indicated that both species occupy the same habitat and compete for space. I postulate that this competition has resulted in the marked differences in morphology and behavior between the two species which ensures an adequate food supply for the young, particularly for the Sora (Table 6). There is ample evidence that the adults of the two species do not compete for food (Horak 1970). The bulk of the Sora's diet is seeds, whereas the bulk of Virginia Rail's food is aquatic arthropods. However, the chicks of both species are fed invertebrates.

I suggest that the short-billed Sora is much less efficient than the long-billed Virginia Rail in gathering invertebrates for the chicks. Soras search for food by raking duckweed mats with their feet or pulling aside floating vegetation with their bill and visually checking for food. Virginia Rails search for food using their tactile sense, running their bill through duckweed mats and under floating vegetation. Thus Virginia Rails could feed under debris Soras could not move and in the entire thickness of duckweed mats.

I further suggest that Soras ensure adequate food for the young by rigorously defending a well-defined territory against other species of rails, enhancing territorial defense with displays using conspicuous plumage, prolonging the period of chick-feeding by staggering their hatching, and feeding only younger chicks unable to feed themselves.

Territories were defended more rigorously by Soras than by Virginia Rails, thus: (1) boundaries of territories were better defined by Soras than by Virginia Rails, (2) Soras exhibited a larger repertoire of aggressive displays performed primarily at the boundary of territories than did Virginia Rails (Kaufmann 1983), (3) the facial pattern of Soras is more striking in the spring and probably reinforces boundary threat displays, and (4) Soras defended the territories inter- and intra-specifically, whereas Virginia Rails defended primarily intra-specifically.

Soras appeared to be more versatile than Virginia Rails in the production of young. This versatility is reflected by a greater variation in clutch size, and combining a large clutch size with initiation of incubation before completion of the clutch, resulting in a prolonged period of hatching.

Hatching asynchrony is the usual condition among the altricial passerines, raptors, the

TABLE 6. Differences in morphology and behavior between Sora and Virginia Rails.

	Sora	Virginia Rail
Main food of adults	Seeds	Invertebrates
Main food of young	Invertebrates	Invertebrates
Territorial defense	Rigid boundaries; boundary displays (Swanning); defends against all rails	Large territory with less defined boundaries; no Swanning displays at boundaries; defends primarily against its own species
Bright plumage of adult	Bright yellow bill, black mask with black eyes; white edged scapulars	Reddish-brown lower mandible
Seasonal changes in colors	Bill becomes bright yellow and eyes darken in spring	Lower mandible is more reddish in spring
Average clutch size	10.5 eggs	8.5 eggs
Maximum clutch size	18 eggs	13 eggs
Staggering of hatching	2-17 days, 7.5 average	1-5 days, 2.0 average
Bright plumage and soft parts of young	Red cere, bald head, ivory bill, black inside of lower mandible, and orange beard	Slightly bald head, ivory bill with black band
Reactions of young to adult	Immobile begging posture	Runs toward parent
First adult aggression toward young	Second week	Fourth to eighth week
Reaction of adults to distress calls of young	None	Rescues wet young by carrying it in bill

Ardeidae, and gulls (Lack 1968; Clark and Wilson 1981; Moch 1984). Lack and Lack (1951) first proposed the "brood reduction hypothesis" to explain hatching asynchrony. By producing young of different ages, the older nestings will compete with younger (and smaller) siblings if food is in short supply. As a result, the number of offspring is adjusted to the available food supply. This is expected to be advantageous in environments in which the food supply for the young cannot be predicted before the time of egg laying. The nestlings lost will be the ones in which the least parental care has been invested (Howe 1978). A second explanation is the "predation hypothesis." By incubating before the completion of the clutch, the parents hide and defend the eggs from predators at an earlier stage, and speed up the time of fledging for at least some of the young (Hussell 1972). The mathematical model of Clark and Wilson (1981) predicts that most bird species should commence incubation before the last egg is laid to avoid predation. A third explanation is the "peak load reduction hypothesis," where asynchrony is a means by which parents spread out the peak food demands of their offspring by spreading out hatching times. These hypotheses are not mutually exclusive, and clearly there may be several advantages to species which hatch their eggs asynchronously.

I believe the main advantage of hatching asynchrony in rails is "peak load reduction." Unlike altricial species (or species as gulls which behave in an altricial manner in that food must be carried a considerable distance), the precocial rail chicks followed their parents in the marsh and begged when hungry. Half of the brood followed each parent, and begging young were invariably fed. The young soon acquired the ability to eat food placed in front of them and to peck at floating items, but the ability to capture live foods took longer. The Sora chicks gradually increased their intake of readily available plant materials.

The behavior and coloration of the Sora chick probably have adapted with the staggering of hatching. The bright plumage and soft parts of the young, combined with begging movements and calls, appear to stimulate the parents to feed the youngest of the brood which are least able to feed themselves. Older chicks that have lost their bright coloration avoid their parents while brightly colored siblings are fed by them.

Bright coloration of chicks appears throughout Rallidae, and is more common in recently specialized genera, e.g. *Fulica*, than in the more primitive genera, e.g. *Rallus* (Boyd and Alley 1948). These authors suggested that the coloration of the chicks served to induce feeding by the parents, but they did not consider appeasement or selective feeding of the brood in species with pronounced staggered hatching. They did note, however, that European Coot chicks begged at the approach of their parents, and that there was a close coloration between the state of the head coloration and the development of independent feeding in the young. The full brilliance of the chick's head coloration peaked at about 3 d, when the chicks were most dependent upon the adults. As independence increased, the brilliance of the head coloration and intensity of the begging diminished.

Further work on the breeding biology of other species of Rallidae is necessary before the full significance of the head coloration of chicks is understood. I propose that head coloration should be most brilliant in: (1) the more aquatic species in which the chicks are heavily dependent upon adults for food; (2) the plant- and seed-eating species, where the adults are likely to be less proficient in providing invertebrate food for the young; (3) species with large clutch sizes and staggered hatching; (4) those species which are highly aggressive in territorial defense; (5) habitats where competition from invertebrate-feeding rails is present. A comparison of the behavior of species of rails which have geographic variation in head coloration in the chicks of the various subspecies might be especially instructive.

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Status of the Hoary Mountain Mint, *Pycnanthemum incanum* (Lamiaceae), in Canada*

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The Hoary Mountain Mint (*Pycnanthemum incanum*) reaches its northern limit of distribution in southern Ontario. Only one extant station is known in Canada, and it is located in a site which may be subject to human disturbance. For this reason, it is considered to be an endangered element of the Canadian flora. The extant site supports other species with southern and western affinities and probably represents a relict flora dating from the time of glacial Lake Iroquois. This species had not been seen in Canada since the turn of the century until it was rediscovered in 1981.

Key Words: *Pycnanthemum incanum*, Hoary Mountain Mint, Ontario, endangered, distribution, population size.

The Hoary Mountain Mint, *Pycnanthemum incanum* (L.) Michx., belongs to a complex of southeastern species which have received varying taxonomic treatments. There is considerable morphological variability within the complex. However, the Ontario plant is the typical form as defined in the monograph by Grant and Epling (1943). This species bears little resemblance to the other species of the genus occurring in Ontario [e.g., *P. pilosum* Nutt. (Hairy Mountain Mint), *P. verticillatum* (Michx.) Pers. (Torrey's Mountain Mint), *P. virginianum* (L.) Durand & Jackson (Virginia Mountain Mint)].

Pycnanthemum incanum has a high natural rubber content and may have some potential as a rubber-hydrocarbon crop (Buchanan et al. 1978). The natural oils of a related species, *P. albescens* T. & G., have odor-blocking and antifungal properties (Eickholt and Box 1965). Pellett (1947, 1950) also noted that *P. pilosum* is a rich source of natural oils and suggested that it could be cultivated for this purpose. A tea prepared from *P. pycnanthemoides* (Leavenw.) Fern. has been claimed to have medicinal value (Deam 1940), and Mesquaki Indians have used the leaves and roots of *P. pilosum* in medicines and to scent traps (Pellett 1947).

Pycnanthemum species are also highly favoured by bees for the production of honey, and the composition of the nectar reduces the likelihood of granulation in the resulting honey (Pellett 1950; Wykes 1953). The raw extract of *P. incanum* acts as a feeding deterrent to soil-borne pests of crops such as the Wireworm (*Melanotus communis*) and the Southern Corn Rootworm (*Diabrotica undecimpunctata howardi*) (Villani and Gould 1985; Villani et al. 1985).

Pycnanthemum incanum is an erect, densely hairy perennial, with stems about 1 m tall rising from rhizomes and branching in their upper portions. Its leaves are ovate to oblong, few-toothed, ca. 4.5-11 cm long and 1.5-5.5 cm wide on petioles 5-15 mm long, and are whitened beneath with dense, fine hairs. The lower leaves are usually green above, but upper leaves and bracts are whitened on both surfaces. Individual pedicels of the flowers are evident within the hemispherical glomerules found at the ends of the branches or rising from the upper leaf axils. The calyx is densely and finely hairy and is somewhat irregular in shape. The corolla is distinctly bilabiate and white with purple spots. The leaves, bracts and calyx are covered with shiny, sessile glands, and the plant has a distinct, fragrant, minty aroma (Grant and Epling 1943). Figure 1 provides an overview of the upper portion of a flowering stem from the Canadian population.

Distribution

Pycnanthemum incanum is widespread and relatively common throughout the major portion of its range in the eastern United States, from Massachusetts and Vermont to northeastern Ohio, south and west to southern Illinois, southeastern Missouri, and southern South Carolina (Figure 2). One Canadian station, in southwestern Regional

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*Based on a COSEWIC status report by the author. Copies of the complete report are available at cost from the Canadian Nature Federation, Suite 203, 75 Albert Street, Ottawa, Ontario K1P 6G1. Endangered status was approved and assigned by COSEWIC on 8 April 1986.

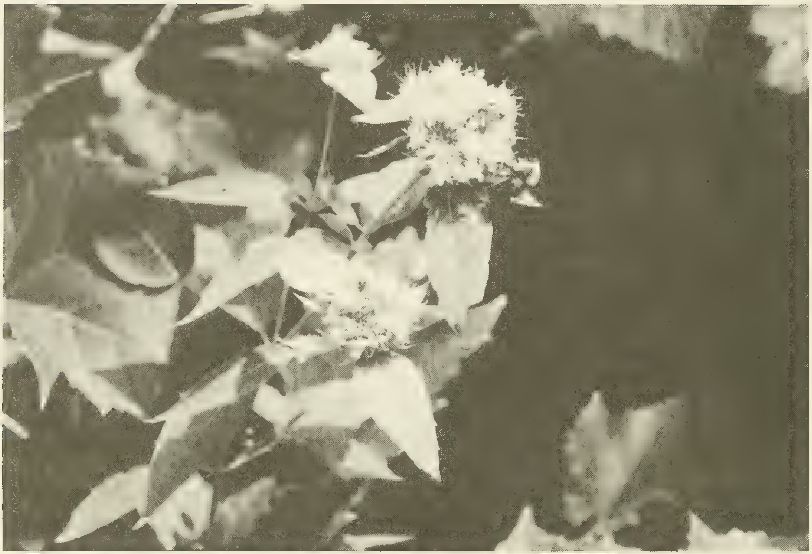

FIGURE 1. Upper portion of a flowering plant of *Pycnanthemum incanum*, Hoary Mountain Mint, at Burlington, Ontario, 11 August 1984.

Municipality of Halton at the western end of Lake Ontario, is known (Figure 3). Between the years 1895 and 1900, *P. incanum* was collected in the Brown's Wharf–Bay View area of Hamilton (now in Burlington), Ontario. It was not seen again until 1981, when the author rediscovered it in the same general area in Burlington.

Habitat

The only Canadian station of *P. incanum* is located on a mildly sloping portion of the glacial Lake Iroquois shoreline, near the rim of the steep slope of the present Burlington Bay bluffs. It occurs in the partial shade of oaks (*Quercus* spp.), and in an open, dry area on the slope. Staghorn Sumac (*Rhus typhina* L.) and White Pine (*Pinus strobus* L.) seedlings comprise the only other native woody species at the site. A sample of the surface soil at this site yielded the following data: pH — 7.5; phosphorus — 6 ppm (parts per million of soil); potassium — 35 ppm; magnesium — 98 ppm; calcium — 2129 ppm; texture — coarse.

Several of its associates are members of a relict shoreline flora with southern and western affinities [e.g., *Andropogon scoparius* Michx. (Little Bluestem), *Asclepias tuberosa* L. (Butterfly-weed), *Carex foenea* Willd., *Lespedeza capitata* Michx. (Round-headed Bush-clover)]. This assemblage of species probably developed during the existence of Lake Iroquois, when direct contact with the Appalachian, Coastal Plain, and midwestern floras may have been facilitated. The open or partially shaded habitat is characteristic of the species throughout its range.

General Biology

Pycnanthemum incanum flowers between mid-July and mid-September in New England (Seymour 1969). This range of dates is corroborated by specimens from throughout the range of the species, including those from Burlington. The evidence of reproduction in the Burlington population is scant. A few young vegetative stems, apparently arising as offshoots from mature rhizomes, indicate that some vegetative reproduction occurs. A number of potential pollinators (Hymenoptera) visited flowers in 1984, so that the possibility of reproduction by seed exists in this population. *Pycnanthemum incanum* is known to

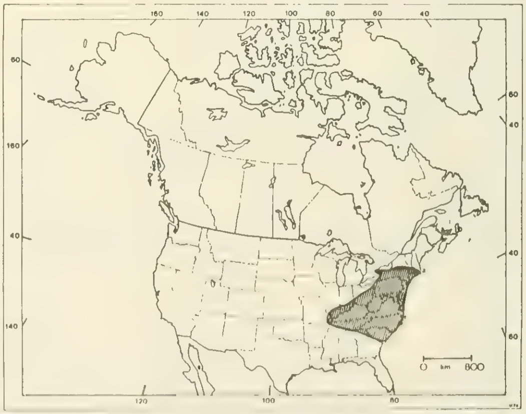

FIGURE 2. Distribution of *Pycnanthemum incanum* in North America.

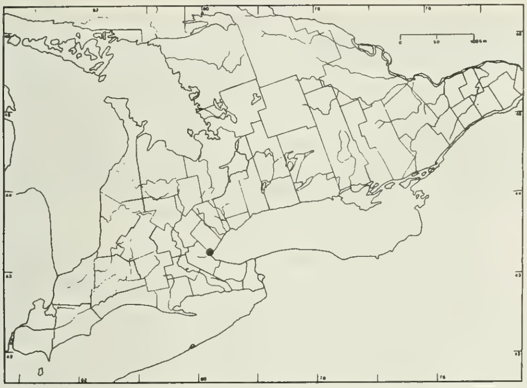

FIGURE 3. Distribution of *Pycnanthemum incanum* in Ontario.

be self-compatible (Chambers 1961, 1962), so that the lack of nearby populations does not affect the probability of sexual reproduction. Although it seems unlikely because of the number of flowers produced and the number of plants present at the site, it is possible that effective rates of pollination could be reduced due to protandry.

Hybridization experiments with various *Pycnanthemum* species were facilitated by their protandrous flowering behavior, which eliminated the necessity to emasculate flowers (Chambers and Chambers 1971). Hybrids between *P. incanum* and other closely related species in the genus are known, but they are generally weak and exhibit meiotic irregularities (Chambers and Chambers 1971). Since no other species occur at the Burlington site or anywhere nearby, there is no possibility of hybridization there.

Population Size and Trends

The single Canadian population of *P. incanum* contained 41 stems in 1984. Five of these were young vegetative stems that appeared to be arising as offshoots from the larger flowering plants. None of the young stems appears to have arisen from seed. As noted above, this does not preclude the possibility of reproduction from seed, but no evidence of this was detected in the Burlington population.

Several of the stems in this population are being crowded and overshadowed by aggressive alien shrubs such as *Berberis vulgaris* L. (Common Barberry) and *Lonicera tatarica* L. (Tartarian Honeysuckle). The fate of these stems is uncertain, since *P. incanum* is known to occur in thickets and disturbed habitats further south.

Limiting Factors

The continued existence of *P. incanum* in Canada may depend on the maintenance of openings at the Burlington site, perhaps by controlling the aggressive spread of alien shrubs. Since the site borders on an active cemetery, there is also the possibility that dumping of compost over the edges of the banks could adversely affect the population. A small path through the population also allows for the possibility of trampling of the remaining plants.

The fragrance and beauty of mature plants and the high quality of the honey produced from members of this genus might make this population a target for gardeners and apiculturists.

Special Significance of the Species

The potential economic benefits that this species may provide (alluded to in the Introduction) make it a species warranting further study. It is also a member of a species complex which is still not well understood taxonomically. Preliminary flavonoid studies have suggested close relationships among the taxa in the *P. incanum* complex (Carr and Hunter 1973), but these data have not yet been reconciled with the full range of morphological variability found in the complex. The *P. incanum* complex remains critical in terms of understanding variability patterns, speciation, and evolutionary relationships. A reconsideration of generic or subgeneric limits and relationships may also be warranted, based on the studies of Chambers and Chambers (1961, 1962, 1971), which showed that ploidy levels and basic chromosome numbers differ among the species complexes within *Pycnanthemum*.

Protection

There is no legal protection in any form for *P. incanum* in Canada. It is considered to be of special concern in Indiana (Bacone and Hedge 1980), and it is very rare in the Niagara Frontier region of New York (Zander and Pierce 1979; Zenkert 1934). It had been listed as extinct in the Canadian portion of its range by L. Kershaw, J. K. Morton, and J. M. Venn (1976. A list of rare or endangered species in the Canadian flora — vascular plants. Unpublished computerized list, Department of Biology, University of Waterloo, Waterloo, Ontario) and provincially rare (possibly extirpated) in Ontario (Argus and White 1977), but it is extant at one site. None of these listings afford any protection.

Evaluation of Status

Pycnanthemum incanum is considered to be endangered in Canada. It occurs at a single site, and that population is under pressure from encroaching alien shrubs, a small foot-path, and dumping of compost. Although there may be limited vegetative reproduction in this population, there is no evidence of sexual reproduction. Some mitigative measures will probably be necessary to retain this species as a member of the Canadian flora.

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Notes

The Atlantic Spanish Mackerel, *Scomberomorus maculatus*, New to Nova Scotia and Canada

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Gilhen, John, and D. E. McAllister. 1989. The Atlantic Spanish Mackerel, *Scomberomorus maculatus*, new to Nova Scotia and Canada. Canadian Field–Naturalist 103(2): 287–289.

A single Atlantic Spanish Mackerel, *Scomberomorus maculatus* taken by Victor Kiley off Sauls Island 44° 28′ 25″N, 63° 47′ 00″W, 4 October 1985, is the first record for Canadian waters. The species has previously been taken north as far as Monhegan Island, Maine. Spots on its sides, a black area on the front of the first dorsal fin and high vertebral count distinguish it from other Canadian Scombridae. Its occurrence in Nova Scotian waters does not appear to be explainable by passive transplant in the Gulf Stream as is invoked for northern records of less active swimmers.

Key Words: Atlantic Spanish Mackerel, Thazard atlantique, *Scomberomorus maculatus,* Sauls Island, Nova Scotia.

A fish taken by Victor Kiley, off Sauls Island, the Prospect area of Halifax County, Nova Scotia at 44° 28′25″N, 63° 47′00″W, on 4 October 1985, is here identified as the Atlantic Spanish Mackerel, *Scomberomorus maculatus* (Mitchell, 1815). This substantiates the record, cited from this paper in manuscript, in Scott and Scott (1988) and previously unknown from Canadian waters. The Atlantic Spanish Mackerel has been commonly reported north only to Cape Cod (Collette and Russo 1984), although it has been taken at Lynn, Massachussetts, and at Monhegan Island, Maine (B. B. Collette, personal communications to DEM 1987). The specimen is catalogued as Nova Scotia Museum 985-85-1(1). Its preserved total length was 375 mm, fork length 325 mm, and standard length 310 mm (Figure 1).

The King Mackerel, *Scomberomorus cavalla* (Cuvier, 1829) has been the only species of the genus previously known from the Atlantic coast of Canada (Legendre 1978). The sides in this species are plain silver, without bars or spots, while the sides in the Atlantic Spanish Mackerel are spotted. The Atlantic Spanish Mackerel lacks a dip in the lateral line.

The following account follows the format used

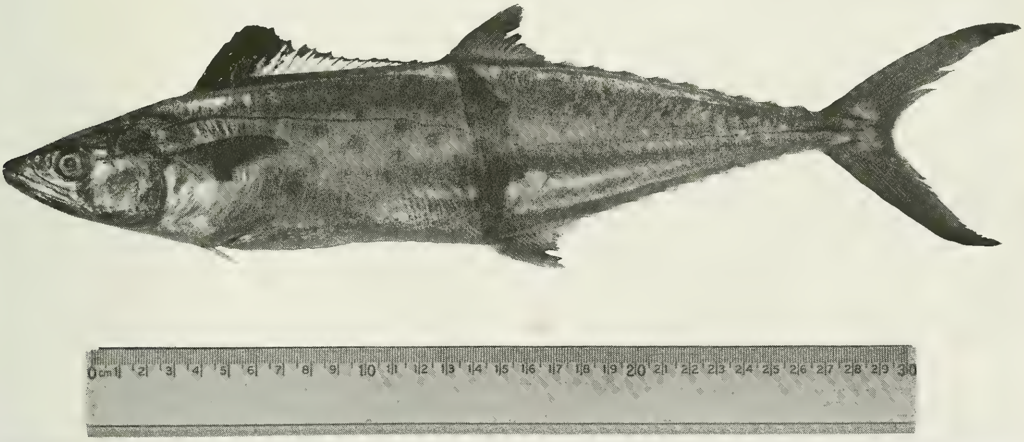
0 cm 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

FIGURE 1. Atlantic Spanish Mackerel, *Scomberomorus maculatus*, captured in a gill net, off Sauls Island, Halifax County, Nova Scotia by Victor Kiley on 4 October 1985.

in Leim and Scott (1966). Collette and Russo (1984), Collette and Nauen (1983), and Collette, Potthoff, Richards, Ueyanagi, Russo and Nishikawa (1984) placed the Spanish mackerel genus *Scomberomorus* in the tribe Scomberomorini of the subfamily Scombrinae, itself placed in the mackerel family, Scombridae. In the following description where there is a single count or body proportion it is for our specimen; values in parentheses are from Collette and Russo (1984).

Atlantic Spanish Mackerel, *Scomberomorus maculatus* (Mitchill 1815), Thazard atlantique

Description: Body fusiform, elongate, moderately compressed. Caudal peduncle carries three keels on each side, one median; maximum body depth about 5 times in standard length (SL). Head entering 8 times in SL, pointed, mouth terminal, end of lower jaw extending just past orbit; a row of large triangular knifelike teeth in the jaws, patches of fine teeth on palatines and vomer; no teeth on tongue. Snout shorter than rest of head. Orbit entering 6.6 times in head length, surrounded by transparent eyelid. Gill rakers moderately long, 2 upper plus 10 lower (1-4 + 10-11 = 10-15 total). Two dorsal fins followed by finlets, 1st low, triangular, 18 (17-19) flexible spines, originating over the pectoral fins, 2nd dorsal, 18 soft rays (17-20), short, following immediately after spinous dorsal, followed by 9 (7-9) finlets equally spaced between the 2nd dorsal and the caudal fin; caudal large, lunate; anal 20 (17-20), followed by 9 (7-10) finlets of the same size dorsal finlets; pectoral short, triangular, with 22 (20-23) rays, inserted high on the side just behind the gill opening; pelvics small, ventral, just behind insertion of pectoral fins, 4.9% of fork length (3.6-5.9%). Scales small, skin smooth, no anterior corselet developed. Gas bladder absent. Vertebrae 21 precaudal plus 31 caudal, total 52 (21-22 plus 30-31 for total of 51-53). Lateral line high anteriorly, descending under the 1st dorsal fin, then following along in a midlateral course with small waves.

Coloration: The body of our specimen was dark blue above, lighter and silvery on the sides and below with bronze spots (turning dark on preservation), each smaller than the orbit on the sides. The second dorsal, caudal and pectoral fins were bluish black when the specimen was fresh. The 1st dorsal is dark back to the 7th ray, the 2nd dorsal is dark, the pectoral is dark distally and all the caudal fin is dark. Collette and Russo (1984) describe the typical coloration as follows: Dark bluish above, silvery below, sides marked with about 3 rows of round to elliptical dark spots (orange in life); first dorsal fin black anteriorly and at distal margin posteriorly, basal part of posterior membranes white.

Distinctive Characters: The Spanish mackerels are distinguished from other Canadian species of the mackerel family, Scombridae, by the 1st and 2nd dorsal fins being in contact, the slenderness of the body, by the presence of a median keel on the caudal peduncle (also present in tunas), by the long low dorsal fin, and by the spots on the sides of the body. It is distinguished from other Spanish mackerels by the lack of a dip in the lateral line (it descends gradually to the midline of the caudal peduncle), the high number of vertebrae (51-53), more gill rakers (usually 11 or more) than in *S. cavalla* (usually 10 or less), and possession of spots on the sides.

Size: The maximum weight in the scientific literature is 4.8 kg, a specimen 77 cm in fork length. But the all-tackle angling record is a 4.97 kg fish taken at Oak Bluffs, Massachussetts. Females grow larger than males.

Distribution: The previously known range was reported as seasonal along the Atlantic coast of United States from Cape Cod to Miami, Florida, and the Gulf of Mexico coast from Florida to Yucatan (Collette and Russo 1984). Our record extends the known range northeastwards from Manhegan Island, Maine.

Biology and Economics: This species inhabits the upper layers of the sea and migrates in large schools over great distances along the shore. As temperatures warm the Atlantic Spanish Mackerel moves north from Florida to Rhode Island between late February and July and back in fall. It overwinters off Florida. Schools also migrate westward in early spring, reaching Texas in late March.

The Atlantic Spanish Mackerel spawns from May to September in waters of less than 50 m depth over the inner continental shelf of Texas, from July to September off Florida, and from late August to late September in the northern part of its range. Eggs, 1 mm in diameter, hatch in 15½ hours at 29°C (Fritzsche 1978). Larvae have been found in temperatures between 19.6-29.8°C and salinities of 28.3-37.4 ppt. The young grow to 18 cm in the first year, 32 cm in the second, 46 in the third, 56 in the fourth and to 57 cm in the fifth year. This growth data suggests that our specimen was between 3 and 4 years old. Females mature by 3 years, some at 1 or 2 years of age (Fritzsche 1978).

Food consists mainly of small fishes with lesser quantities of penaeoid shrimps and cephalopods. Clupeoids such as Menhaden, Alewives, Thread Herring and anchovies are important.

The Atlantic Spanish Mackerel is a valued fish to recreational and commercial fisheries in the United States and Mexico. Over 92% of the total U.S. catch has been landed in Florida. The species is second in volume among Mexico's Gulf of Mexico fisheries with an annual production of 4900 metric tons in the period from 1968-1976. Most of the catch is consumed fresh, frozen or smoked.

Discussion

Our specimen can be distinguished from the only other known Canadian species of Spanish mackerel by the presence of spots, by the black area on the front of the first dorsal fin, the straight lateral line without a dip under the second dorsal fin, and the caudal vertebrae counts. Our specimen does not differ in any significant way from the description of the species in Collette and Nauen (1983).

It is difficult to explain the occurrence of this specimen in Nova Scotia in October. Migrations northwards take place in the United States between late February and July with return in the fall; the Nova Scotian occurrence does not fit in with the known migratory pattern. The occurrence of other tropical fishes in Nova Scotian waters has been explained by postulating transport northwards in the Gulf Stream and shorewards in gyres which break off the Stream. Passive transport does not seem as applicable to an active swimmer such as an Atlantic Spanish Mackerel.

Acknowledgments

We thank Victor Kiley who caught this specimen and generously furnished it to J. G., Ron Merrick who took the photograph and Mrs. Jadwiga Frank who took the x-ray.

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Courtship and Nesting Records for Spotted Turtles, *Clemmys guttata*, in the Mer Bleue Bog, southeastern Ontario

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Chippindale, Paul. 1989. Courtship and nesting records for Spotted Turtles, *Clemmys guttata*, in the Mer Bleue Bog, southeastern Ontario. Canadian Field–Naturalist 103(2): 289–291.

Two instances of courtship between Spotted Turtles, *Clemmys guttata*, in the Mer Bleue bog are described. On 30 May 1985 an adult male was seen nudging and biting an adult female, but no mating was observed; on 17 June 1985 courtship and brief mating of an adult pair were noted. A single nesting record for *C. guttata* in the Mer Bleue is presented: an adult female laid one egg in a shallow hole in a hummock of moist sphagnum moss on 29 June 1986. Other reproductive behaviour records for this species in Ontario are reviewed.

Key Words: Spotted Turtle, *Clemmys guttata*, courtship, nesting, Mer Bleue, Ontario.

The Spotted Turtle, *Clemmys guttata*, occurs in still, shallow-water habitats throughout much of eastern North America. In Canada, *C. guttata* is known from numerous locations in southern Ontario, but is more rare and possibly disjunct in scattered occurrences in eastern Ontario and Quebec (Cook et al. 1980; M. J. Oldham. 1982. The status of the spotted turtle (*Clemmys guttata*) in Canada. Ontario Ministry of Natural Resources, Toronto. 88 pages).

Populations in the central and southern portions of this turtle's range have been well studied (e.g. Ernst 1976), but little is known of the ecology and, in particular, of the reproductive habits of this species at the northern periphery of its distribution. This note describes only the third observation of nesting by a Spotted Turtle in Ontario and two instances of courtship.

In Mer Bleue, Spotted Turtles are known from the vicinity of a few small, sandy islands in the bog centre, where they inhabit shallow channels and pools (Cook et al. 1980; Chippindale 1984) and 49 individuals have been marked in a study carried out in 1984-1986 (Chippindale 1989).

Courtship was observed only twice. On the afternoon of 30 May 1985, an unidentified (presumed) adult male circled, nudged, and bit a previously marked adult female (carapace length 91.9 mm, plastron length 87.6 mm) in water 15-20 cm deep for approximately 15 minutes, after which the female swam away. Weather was clear and sunny, with an ambient air temperature of 22.5°C and water temperature ranging from 16.5°C at the surface to approximately 10.0°C at 20 cm depth. On 17 June 1985, a previously marked adult male (carapace length 101.9 mm, plastron length 82.1 mm) chased an unidentified (presumed) adult female approximately 10 m along a shallow (0.5 m deep) channel from 1410-1415 h. He then mounted her despite much initial struggling on her part and copulated for 2 to 3 minutes, after which she fled another 4 m and buried herself in lose peat at the bottom of the channel.

Ernst (1967, 1970) described courtship and mating in Pennsylvania *C. guttata*. He observed individual females being chased 30 to 50 m by one to several males, in shallow water and sometimes on land. Males sometimes bit females on the legs and tail during such chases. Copulation, which lasted 15 to 30 minutes, occurred under water at water temperatures as low as 8.5°C. Ernst (1970) also reported aggression between males competing for the same female. Chippindale (1989) cited two previous records of breeding activity in Ontario: one instance of attempted mating by a pair at 12-Mile Bay in Parry Sound District on 24 July 1977 and an observation by D. C. Smith and R. Spurr of copulation in a slough near Ipperwash Beach in Lambton County on 7 May 1977.

Nesting was observed in Mer Bleue at 1714 h on 29 June 1986. A previously unmarked adult female (carapace length 105.1 mm, plastron length 97.8 mm) was found on top of an exposed hummock of sphagnum moss approximately 10 m from an open-water channel adjacent to one of the islands. The weather was sunny, having cleared after a heavy rainstorm about two hours earlier, and the ambient air temperature was 22.4°C. The turtle was positioned with her hind legs stretched out on either side of a hole three cm in diameter in the moss. Her tail extended into the hole. After 14 minutes in this position, the turtle covered the hole loosely with moss and then crawled down the side of the hummock. There, she rested in the shade of a Leatherleaf, *Chamaedaphne calyculata*, shrub for five minutes, then buried herself in sphagnum. Inspection of the hole revealed a single egg, 3.28 cm × 1.85 cm (at its widest point), 6.5 cm deep in the hole. Later visits to the nest site indicate that this egg was probably inviable, as it was still intact with no visible signs of development in late October 1986.

Incubation time for Spotted Turtles averages 76 days in southeastern Pennsylvania (Ernst 1970) and 70 days in Massachusetts (Belmore 1980); a clutch incubated artificially by Babcock (1919) took 82 days to hatch. In Massachusetts, where mating occurs in March to early April, egg laying ocurs in June (Belmore 1980); in southeastern Pennsylvania, courtship occurs in March through early May, mating has been observed in March and April, and egglaying occurs in late May through June (Ernst 1976). Carr (1952) reported June as the nesting month. Adler (1961) observed nesting by two captive *C. guttata* in Indiana on 11 July 1960.

Logier (1925) reported a female Spotted Turtle digging a nest at Point Pelee on 22 June 1920. During late afternoon-early evening on 15 June 1986, two females were found digging nests at Long Point Provincial Park and several others were seen leaving the water and moving toward higher ground, presumably to lay eggs (W. Weller, personal communication).

A photograph by T. Mehisto of a female laying eggs appeared in the *Ontario Herpetological Society News* (Number 5, September 1986). E. Jankowski reported a female preparing to nest on a newly created trail at Big Creek Marsh on 14 June 1986 (Chippindale 1989). D. A. Sutherland found three newly emerged hatchlings on a dike at Big Creek Marsh, Haldimand-Norfolk County, on 5 October 1986 and G. R. Francis reported another hatchling at the same locality on the same day (Chippindale 1989). The incubation periods for the eggs from which they hatched are unknown.

Spotted Turtle clutch sizes average three to five eggs in more southern populations (Ernst 1970; Belmore 1980); the clutch of the turtle photographed at Long Point contained five eggs. Adler (1961) reported an exceptionally large clutch of eight eggs laid by a large captive *C. guttata* in Indiana. The single egg laid by the Mer Bleue turtle may have been the result of aberrant reproductive behaviour; e.g. it may have been an inviable egg that was voided (S. J. Darbyshire, personal communication), although apparent excavation of a nest would seem to contradict this. Type of nesting site is variable elsewhere, ranging from well-drained soil (Ernst 1970) to sandy sod (Logier 1925) to grassy tussocks (Belmore 1980). At Long Point, the photographed turtle laid eggs in a sandy area, while the other dug a nest on a gravel road shoulder (W. Weller, personal communication). In Mer Bleue, the sandy islands appear to offer suitable nest sites similar to those used elsewhere. On 26 May 1986 at 1815 h a female was observed wandering across an island after rain, perhaps seeking a place to nest; turtles in the Mer Bleue have not been seen on the islands on any other occasion.

Although the fact that only one instance of nesting has been observed in four years of study might suggest that the reproductive rate is low at Mer Bleue, even in areas where Spotted Turtles are relatively abundant nesting records appear to be rare. Ernst (1976) found that 12.1% of turtles in his Pennsylvania study population were under one year of age, but no turtles under the apparent age of three years have been found in the Mer Bleue (ages estimated by scute ring counts). However, young *C. guttata* are very secretive (Belmore 1980) and may simply have been overlooked.

Acknowledgments

F. R. Cook and H. G. Merriam deserve special thanks for their advice and encouragement throughout this study. S. J. Darbyshire and several anonymous reviewers made many helpful suggestions regarding this manuscript. My research was supported by the National Capital Commission Conservation Section, and I thank Stew Hamill, Connie Gaudet, and Joanne Dean for their help. Funding in 1985 was provided by an NSERC summer undergraduate research grant to the author.

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Additions to the Vascular Flora of Manitoba

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Johnson, J. D. 1989. Additions to the vascular flora of Manitoba. Canadian Field-Naturalist 103(2): 291–293.

Five previously unreported vascular plant species were collected during an ecological survey in the boreal forest regions of Manitoba: *Cladium mariscoides* (Twig Rush), *Juncus stygius* var. *americanus* (Marsh Rush), *Lycopodium sabinaefolium* var. *sitchense* (Ground Fir), *Panicum columbianum* var. *siccanum* (Columbian Panic Grass), and *Rhynchospora alba* (white Beak-rush).

Key Words: Manitoba, new records, vascular plants, boreal forest.

A number of interesting vascular plant collections were made during an ecological survey in the boreal forest regions of Manitoba. After consulting *The Flora of Canada* (Scoggan 1978) and surveying a number of herbaria [CAFB, CAN, DAO, MMMN, and WIN: acronyms follow Holmgren and Keuken (1974)], I found that five of the collected species appear to be first records for the province.

Nomenclature in this listing follows Scoggan

(1978). Numbers given in brackets are voucher numbers. All collections are those of the author, except as noted. Voucher specimens are deposited in the herbarium of the Northern Forestry Centre in Edmonton (CAFB). Collection localities are indicated in Figure 1.

Cladium mariscoides (Muhl.) Torr., Twig Rush. 6.5 km N of Buffalo Bay (Lake of the Woods): 49°14′N, 95°12′W; string fen (W. Smith MIN 9217). Provincial Road 214, 8 km N of Seddon's Corner; 50°08′N, 96°17′W; spring fen (5967). Provincial Road 233, 3.5 km W of Washow Bay; 51°07′N, 97°03′W; graminoid fen (5968). This species occurs in fresh or brackish fens, swamps and marshes, and along shores. Its main distribution is eastern, from the eastern end of Lake Superior in Ontario, to Quebec, Newfoundland, New Brunswick and Nova Scotia and south to Minnesota, Illinois, Alabama and Florida (Scoggan 1978). There are two isolated records from Saskatchewan (Maher et al. 1979). The Manitoba occurrences help to fill in the distribution of the species northwestward from Ontario and Minnesota.

Juncus stygius L. var. *americanus* Buch., Marsh Rush. Provincial Road 391, 10 km N of Wekusko; 54°35′N, 99°47′W; string fen (5617). This species occurs along peaty lakeshores and in medium-to-rich fens from south-central Alaska and southwestern District of Mackenzie to northern and central Saskatchewan, southeast District of Keewatin, Ontario, Quebec, Labrador, Newfoundland, New Brunswick and Nova Scotia, south to British Columbia, southwestern Alberta, Minnesota, New York and Maine (Scoggan 1978). This species was also encountered at three locations in central Saskatchewan during the course of this study (Nikik Lake, Dore Lake, and Nipekamew River). It is considered rare in that province (Maher et al 1979).

Lycopodium sabinaefolium Willd. var. *sitchense* (Rupr.) Fern., Ground Fir. Lynn Lake; 56°51′N, 101°04′W; Jack Pine (*Pinus banksiana*) on dry sand (E. T. Oswald 2477). The variety *sitchense* has a transcontinental distribution in northern North America, being found from southern Alaska and southwestern Yukon Territory to British Columbia, Alberta, Saskatchewan, Ontario, Quebec, Newfoundland, New Brunswick and Nova Scotia. It is not known from the Northwest Territories (Porsild and Cody 1980). It is found in woods, thickets, and clearings, often on a sandy substrate. The Manitoba occurrence fills part of a gap in the distribution between northwestern Ontario and northeastern Saskatchewan.

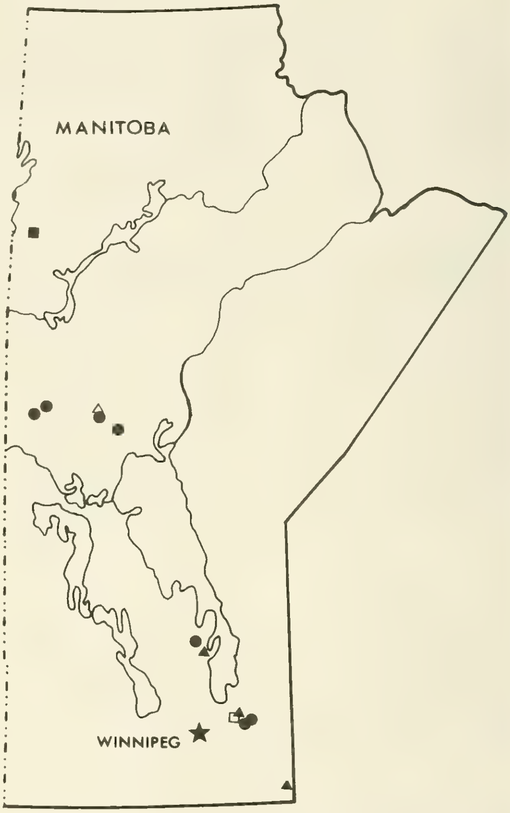

FIGURE 1. Collection localities for *Cladium mariscoides* (▲), *Juncus stygius* var. *americanus* (△), *Lycopodium sabinaefolium* var. *sitchense* (■), *Panicum columbianum* var. *siccanum* (□) and *Rhynchospora alba* (●).

Panicum columbianum Scribn. var. *siccanum* (Hitchc. & Chase) Boivin, Columbian Panic Grass. Highway 44, 11 km E of Seddon's Corner; 50°03′N, 96°08′W; disturbed Jack Pine woods (5917). The genus *Panicum* is one of the more taxonomically challenging of the grass genera, and perhaps for this reason the distribution of a number of the species in the group is poorly known. *Panicum columbianum* occurs on dry or sandy open ground and in thin woods from west of Thunder Bay in Ontario, east to Quebec, and south to Wisconsin, Illinois, Maine, Tennessee and Georgia (Scoggan 1978). The Manitoba collection comes from typical habitat for the species and represents a northwestward extension of the currently known range.

Rhynchospora alba (L.) Vahl, White Beak-rush. Julius Bog; 50°00′N, 96°12′W; graminoid fen (5964). 5 km SE of River Hills; calcareous fen (K. L.

Johnson MMMN 13444, 14385). Provincial Road 325, 17 km E of Hodgson; 51°14′N, 97°19′W; graminoid fen (5965). Highway 10, 12.5 km S of Cranberry Portage; 54°28′N, 101°22′W; spring fen (5653). Highway 6, 9 km N of Hargrave River; 54°28′N, 99°03′W; string fen (5655). 5.5 km N of Wekusko; 54°33′N, 99°47′W; string fen (5654). Provincial Road 391, E of Simonhouse Lake; 54°34′N, 100°58′W; string fen (5652). Although bogs are included in the habitat list for this species (Scoggan 1978), in the area surveyed it prefers mineral-rich sites. In addition to fens, it can be found on shallow wet peats and sands (Scoggan 1978). The distribution of the species covers southern Alaska, British Columbia, Saskatchewan, Ontario, Quebec, southeastern Labrador, Newfoundland, New Brunswick, Prince Edward Island and Nova Scotia, and extends south to California, Idaho, Minnesota, Ohio and North Carolina (Scoggan 1978).

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I would like to thank the following persons at DAO for verifying specimen identifications: P. M. Catling (*Cladium, Juncus, Rhynchospora*), W. J. Cody (*Lycopodium*), and S. J. Darbyshire (*Panicum*). Appreciation is extended to K. L. Johnson at the Manitoba Museum of Man and Nature for providing additional collection localities for *Rhynchospora alba* and other distribution information. I would also like to thank W. Smith of the Minnesota Department of Natural Resources for providing me with locality data for his collection of *Cladium mariscoides.*

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Bald Eagle, *Haliaeetus leucocephalus*, Nest Distribution on Cape Breton Island, Nova Scotia

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MacDonald, Peter R. N., and Peter J. Austin-Smith. 1989. Bald Eagle *Haliaeetus leucocephalus*, nest distribution on Cape Breton Island, Nova Scotia. Canadian Field-Naturalist 103(2): 293–296.

The distribution of Bald Eagle (*Haliaeetus leucocephalus*) nests on Bras d'Or Lake, Cape Breton Island, Nova Scotia, was examined in relation to coastal characteristics. Nest density was negatively correlated with length of coastline/nest whereas shallow water (0-5 m) area correlated positively with nest density. Although nest site parameters were not examined with respect to reproductive success, our results suggest that proximity of nests to the highest quality foraging areas may be a more important measurement than distance to nearest open water.

Key Words: Bald Eagle, *Haliaeetus leucocephalus*, nest distribution, Nova Scotia.

The importance of fish, including benthic species, to breeding Bald Eagle, *Haliaeetus leucocephalus*, populations is indicated by the relative dominance of fish as prey items in many food habit studies (Dunstan and Harper 1975; McEwan and Hirth 1980; Todd et al. 1982; Cash et al. 1985), and consistent occurrence of Bald Eagle nests near water (Whitfield et al. 1974; Gerrard et al. 1975; Todd et al. 1982; Grubb 1980; Andrew and Mosher 1982). The capture of benthic fish by Osprey, *Pandion haliaetus*, and Bald Eagles has been attributed to the vulnerability of bottom-feeders to aerial predators (Swenson 1979; Todd et al. 1982). Haywood and Ohmart (1986) found that the movement of these fish into shallow water or riffles to feed increases their availability to Bald

Eagles, and that eagle nests tend to be in close proximity to such foraging sites. This indicates an important relationship between nest location and physical characteristics of aquatic habitat.

This study, using data collected previously, was undertaken to determine if there was a significant relationship between physical coastal features and the distribution of Bald Eagle nests around Bras d'Or Lake on Cape Breton Island, Nova Scotia. Cash et al. (1985) found that 83% of Cape Breton eagle nests were located along the shores of Bras d'Or Lake, and that fish, predominantly Atlantic cod, *Gadus* sp., constituted 66% of total diet. Nests are not evenly distributed around the lake and concentrations exist in some locations. Clustering of nests is most noticeable where the coastline is irregular, containing numerous islands and inlets, particularly in the Denys Basin-St. Patrick's Channel area, on the lake's northwest corner.

Study Area

Bras d'Or Lake, Cape Breton Island, Nova Scotia, is a 1000 km^2 body of brackish water. There are three outlets to the sea: the Great Bras d'Or and Little Bras d'Or channels and St. Peter's Canal (Cash et al. 1985). The lake contains numerous shoals and depth exceeds 180 m at some points (Roland 1982). Tidal amplitude is generally less than 25 cm.

Methods

Due to the more than 195 Bald Eagle nests on record for Cape Breton, it was necessary to develop a sampling scheme that would encompass various nest densities. Using standard 1:50 000 scale topographic maps, we divided the island into 10×10 km squares. Nest locations were then plotted on the map. Densities ranged from 1 to 24 nests per square (Table 1). All nests known to have been active during the five-year period 1982-86 were included on the maps. Only nests situated around Bras d'Or Lake were considered for analysis; those on the Atlantic Coast were eliminated from the sampling process. This was done on the assumption that distance precluded the use of Bras d'Or Lake as a major foraging area for coastal nesting eagles. All nest densities were sampled, but only 1 square each existed for the 5 highest densities (Table 1). We measured all squares with nest densities of 4 and 5. Five squares from among those with each of 1, 2, and 3 nests/100 km^2, the most numerous densities on the map, were randomly selected as samples.

It was important that sample areas include water over which each nesting pair might search for food. However, situations where nests occurred near a square border did not satisfy this requirement. Little is known about the nature of eagle territories on Bras d'Or Lake, but because of frequent coastline irregularities, it is evident that eagles in some situations could fly short distances over land or water to forage in a location which would be a relatively long distance from the nest if foraging flights to it followed the coast. Thus, we did not assume foraging to be restricted only to coastline continuous from the nest site. Based on available literature on foraging distances (e.g. Hensel and Troyer 1964; Gittens 1968; Whitfield et al. 1974; Sherrod et al. 1976; Grubb 1980) and the physical characteristics of Bras d'Or Lake we established a 10 km radius with its center corresponding to the center of the square. All water area and coastline length within this circle was measured using a dot grid sheet and map measurer, respectively. Area in ha was obtained for two categories of water depth: 0-5 m and >5 m separated by color coding on marine charts. In addition, area of freshwater lakes and rivers was measured for each sample.

Data were tested with the nonparametric Spearman's Rho (Conover 1971) using a one-tailed test because of non-normal distribution.

Results and Discussion

Coastline length in km within each sampled area showed no significant rank correlation with nest density (Table 1). Nest density showed a strong negative correlation with km of coastline/nest ($r_s = -0.85$, $P < 0.0001$).

Analysis was performed on the percentage of total ha made up by a particular water depth category (Table 1). Nest density correlated positively with shallow water ($r_s = 0.44$, $P < 0.025$) and negatively ($r_s = -0.41$, $P < 0.025$) with deeper water (> 5 m). No relationship was found for nest density and freshwater area.

Our analysis showed that Bald Eagle nests on Bras d'Or Lake are more concentrated in extensive shallow water zones, probably as a result of prey availability. The presence of bottom-feeding fish such as cod and Winter Flounder, *Pseudopleuronectes americanus*, in the diet of these eagles (Cash et al. 1985) and the vulnerability of benthic fish species to aerial attack (Swenson 1979; Todd et al. 1982; Haywood and Ohmart 1986) are consistent with this occurrence.

The hypothesis that increased shoreline, created by a highly indented coast, determines eagle nest spacing on Bras d'Or Lake is not supported by the results. No relationship exists between nest density and coastline length; moreover, foraging area actually decreases with increasing nest density, suggesting an abundance of food. Small nesting territories and apparent lack of defensive behaviours at feeding areas, as reported by Gittens (1986), may account for this. High densities of eagle nests in areas of irregular coastline have been

TABLE 1. Percentage area of water depth and of freshwater, coastline length and km coastline/nest in each sampled square, Cape Breton Island, Nova Scotia

No. nests/ 10 × 10 km square	Water depth (%)		Freshwater (%)	Coastline (km)	km coastline/nest
	0-5 m	> 5 m			
24	32.7	67.2	0.1	192.5	8.0
11	32.5	67.2	0.3	124.7	11.3
9	22.7	75.0	2.3	99.6	11.1
8	13.6	82.2	4.2	124.2	15.5
6	19.7	74.4	5.9	70.7	11.8
5	44.7	53.1	2.2	88.9	17.8
5	10.9	88.4	0.7	61.3	12.2
5	9.8	89.4	0.7	103.6	20.7
5	7.4	91.5	1.1	141.0	28.2
4	19.0	75.5	5.5	51.5	12.9
4	5.9	93.7	0.4	123.4	30.8
3	9.0	87.8	3.2	68.3	22.8
3	4.3	78.5	17.2	31.2	10.4
3	10.0	89.9	0.1	137.2	45.7
3	11.7	87.8	0.5	107.1	35.7
3	13.5	86.0	0.5	60.0	20.0
2	17.4	81.2	1.4	87.2	43.6
2	24.0	64.3	11.7	47.6	28.8
2	14.7	84.3	1.0	164.3	82.2
2	3.6	96.4	0.0	71.3	35.6
2	9.2	89.8	1.0	56.8	28.4
1	14.9	82.9	2.2	80.5	80.5
1	3.6	96.3	0.1	66.3	66.3
1	6.9	92.6	0.5	46.5	46.5
1	15.1	81.9	3.0	137.4	137.4
1	11.1	83.2	5.7	102.5	102.5

reported by other authors (Sherrod et al. 1976; Hodges et al. 1984). Sherrod et al. (1976) concluded that nest concentrations in Alaska occurred where restricted visibility, caused by rugged, convoluted coastline, reduced interactions between nests. This explanation is not applicable in the Bras d'Or situation, since nest trees invariably provide considerable viewing distance and instances of pairs visibly nesting in close proximity are common.

Analyses of Bald Eagle nest sites (e.g. Gerrard et al. 1975; Todd 1979; Grubb 1980; Andrew and Mosher 1982) have isolated the most important characteristics common to eagle nests in various North American locations. Eagles tend to nest in tall, strong-limbed trees surrounded by discontinuous canopies, near open water and buffered from human activity. Actual distance of nests from water is not important in terms of reproductive success (Gerrard et al. 1975; McEwan and Hirth 1980; Andrew and Mosher 1982), hence eagle nests are generally well within optimal foraging range (Andrew and Mosher 1982). Although we did not examine nest site parameters with respect to reproductive success, our results suggested that the proximity of nests to highest quality foraging areas may be more important than distance to nearest open water. Further, Swenson et al. (1986) found that in the Greater Yellowstone Ecosystem access to a reliable food source early in the nesting season was a factor common to all breeding areas, whereas other nest site characteristics were highly variable. In light of concern over maintenance or improvement of Bald Eagle habitat, access to food supply becomes increasingly important.

Acknowledgments

We thank G. E. Dickie for his help throughout this work and D. Tosh for statistical advice. We are also grateful to P. C. Smith, J. S. Boates and R. Newell for their helpful comments.

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News and Comment

Editor's Report for Volume 102 (1988)

A total of 114 manuscripts were submitted to *The Canadian Field-Naturalist* in 1988. Publication of the volume was delayed and 102(1) was not mailed until 14 October 1988, followed by 102(2) 5 December and 102(3) 30 December. The volume was completed with 102(4) mailed 28 February 1989.

The increase in total pages continued with 794 in volume 102, 112 more than in 101. At 216 pages, 102(2) was the largest single issue of the journal ever published. The number of research and special contributions is summarized in Table 1, the totals for Book Reviews and New Titles in Table 2, and the distribution of published pages in Table 3. COSEWIC Status Reports on fish and marine mammals were again edited by Bob Campbell and the full cost of pages, tables, figures as well as reprints was paid by the Department of Fisheries and Oceans. Two tributes, to A. L. Rand and A. J. Breitung, appeared in 102(3) as did articles on John Richardson and a contributed editorial "Restoring the Great Lakes".

Liza (Meyboom) Janssen assisted in all those tasks involved with manuscript and galley flow, Elizabeth Morton provided editorial assistance by reading and marking manuscripts, and Louis L'Arrivée proof-read all galleys. Bill Cody ran all business aspects of the journal: budget, author billings and negotiations with the printer, M.O.M., Ottawa. At M.O.M., Emile Holst and Eddie Finnigan and their staffs provided advice as well as setting and printing the journal.

TABLE 1. Number of research and observation manuscripts published in *The Canadian Field-Naturalist* Volume 102 (1988) by major field of study.

Subject	Articles	Notes	Total
Mammals	12	13	25
Birds	17	15	32
Amphibians and reptiles	1	4	5
Fish	6	3	9
Invertebrates	4	2	6
Plants	9	6	15
Other	1	1	2
Total	50	44	94

In addition there were 30 review papers included in News and Comment: 25 COSEWIC reports (1 committee report, and status reports on 17 fish and 7 marine mammals); tributes to and bibliographies of A. L. Rand and A. J. Breitung, tribute to J. Richardson and an editorial "Restoring the Great Lakes".

TABLE 2. Number of reviews and new titles published in Book Review section of Volume 102 by topic.

	Reviews	New Titles
Zoology	43	188
Botany	18	99
Environment	15	129
Miscellaneous	8	54
Young Naturalists	0	124

TABLE 3. Number of pages published in *The Canadian Field-Naturalist* Volume 102 (1988) by section (number of manuscripts in parentheses).

Issue number:	- 1 -	- 2 -	- 3 -	- 4 -	Total
Articles	59 (8)	48 (8)	108 (15)	101 (19)	316 (50)
Notes	19 (10)	15 (7)	27 (13)	28 (14)	89 (44)
News and Comment reports	2 (6)	4 (3)	1 (2)	3 (2)	10 (13)
COSEWIC	96 (13)	129 (12)	- -	- -	225 (25)
Tributes & bibliographies	- -	- -	14 (3)	- -	14 (3)
Other	- -	- -	9 (2)	- -	9 (2)
OFNC Annual Meeting	- -	- -	9 (1)	- -	9 (1)
Book Reviews*	25 (21)	19 (11)	24 (23)	32 (29)	100 (84)
Index	- -	- -	- -	20 (1)	20 (1)
Advice to contributors	1 (1)	1 (1)	- -	- -	2 (2)
Total pages:	202	216	192	184	794

*total pages include both reviews and new titles but figure in parentheses includes only number of reviews.

E. Wilson Eedy coordinated and edited the Book Review section and Harvey Beck compiled the Index. George LaRoi served as coordinator for the Biological Flora of Canada. Our panel of associate editors remained the same: A. J. Erskine (birds), W. O. Pruitt and C. G. Van Zyll de Jong (mammals), C. J. Jonkel (predator-prey relationships), D. E. McAllister (fish), C. D. Bird (plants). S. M. Smith (insects) and E. L. Bousfield (invertebrates). These were assisted by the following additional reviewers who commented on one or more manuscripts though the calendar year: A. W. F. Banfield, D. Belk, M. A. Bigg, J. S. Bleakney, J. M. Bogart, R. W. Campbell, R. R. Campbell, P. M. Catling, W. J. Cody, R. R. Cohen, E. J. Crossman, A. Crowder, H. E. Danks, R. W. Davies, C. Delisle, L. C. Drickamer, C. D. Dondale, J. Eckenwalder, W. E. Godfrey, D. R. Gray, D. M. Green, P. T. Gregory, M. Hammill, V. L. Harms, R. R. Ireland, L. B. Keith, R. H. Krebs, G. L. Kirkland Jr., H. G. Lumsden, J. Madill, A. W. Mansfield, L. D. Mech, J. S. Nelson, D. M. Nettleship, H. Ouellet, W. B. Preston, T. E. Reimchen, R. J. Robertson, D. A. Russell, R. Sattler, F. W. Schueler, S. G. Sealy, A. Stahevitch, K. W. Stewart, P. J. Weatherhead, P. M. Youngman.

My thanks to Bill Gummer, President, and the Ottawa Field-Naturalists' Club Council, to Ron Bedford and the Publications Committee of the OFNC for their support and encouragement and to the National Museum of Natural Science for providing a portion of my space and time as part of its mandate to disseminate information on natural history. Special appreciation is due to Joyce.

FRANCIS R. COOK
Editor

Borealis: A Magazine for Canadian Parks and Wilderness

The Canadian Parks and Wilderness Society (CPAWS), formerly the National and Provincial Parks Association, a private, educational, non-profit organization incorporated under Federal Charter in Canada in 1963, launched *Borealis: The Magazine for Canadian Parks and Wilderness* in the fall of 1988. Dr. Theodore Mosquin, once president of The Ottawa Field-Naturalists' Club and Editor (1967-1972) of *The Canadian Field-Naturalist*, later President of the Canadian Nature Federation and Editor of *Nature Canada*, is the President of the Canadian Parks and Wilderness Society at the appearance of the new magazine. A former publication, *Park News*, issued by the Society for 23 years, is now described as "a quasi-academic journal" in an editorial by the first editor of *Borealis*, David Dodge, in order to contrast its old style with the unique role staked out by its new replacement. Dodge goes on to stress that *Borealis* is not intended as another "nature magazine" but leaves that niche to already established promoters such as *Nature Canada*. Instead, *Borealis* is to be a magazine of "the deepest and most significant issues facing our time" and readers will be "challenged to confront and evaluate" their "own place on earth". It is for "anyone who shares an interest, feeling or concern for the land" and "seeks to uncover, to understand and to report on" the wilderness.

The premiere issue featured "Taiga: Earth's Evergreen Mantle" by J. David Henry, "South Moresby by Kayak" by Thom Henley. "Madawaska: A Land Ethic in the Making" by David G. Dodge. "Bay du Nord" by Jon Lien and Dave Snow, "Alaska 1002" by Ed Struzik, and "Special Report: 50 Books Important to Conservation" by Ron Tibbett, as well as nine "Department" columns, all in sixty-four 11 by 8.5 inch glossy pages extensively illustrated with colour photographs as well as black-and-white-and-grey maps and the odd cartoon or two. The initial cover is a striking green mix of the Studded Leather Lichen (*Peltigera aphthosa)*, Knight's Plume (*Ptillium crista-catensis*) and the more common feather moss (*Hylocomium splendens*) on the floor of a boreal forest contributed by Wayne Lynch, and edged broadly in black.

Borealis is to be published quarterly. Information on the aims of, and membership in, The Canadian Parks and Wilderness Society may be obtained from its National Office, Suite 1150, 160 Bloor Street East, Toronto, Ontario M4W 1B9. Telephone (416) 972-0868.

FRANCIS R. COOK

Book-review Editor's Report 1988 Volume 102

In 1988, the number of books received, reviewed and reviews published has continued at a great pace, although not quite as extensive as the previous record year. This makes it an effort to keep in touch with all of the reviewers and to find new reviewers when required. We remind our reviewers to please keep in touch and let us know when you are interested in reviewing appropriate new titles. I try to keep in touch with everyone, but several hundred reviewers mean this is difficult.

In 1988 we received 107 books, sent 132 to reviewers, received 82 reviews and published 83 in our journal. In addition, 596 New Titles were listed. There are still a large number of the available books (indicated by a dagger beside the listing in the last couple of issues) on my shelves for which we would appreciate expressions of interest from prospective reviewers. Please contact me before you prepare a review, as our policy is to assign reviews to the first qualified requester. Several unsolicated reviews arrived last year which had unfortunately already been reviewed by others.

There are a number of outstanding reviews which are beyond the 3 month deadline for completion. I have tended to procrastinate on chasing after these because of the excessive time needed. If you have been delaying, would you please make an effort to complete the review you have promised. Publishers supply books on the understanding that reviews will be published. Extensive delays hurt our reputation.

WILSON EEDY
Book-review Editor

Letter to the Editor: The Status of the Sea Mink

I recently read with interest a paper by R. R. Campbell entitled "Status of the Sea Mink, *Mustela macrodon* in Canada" in *The Canadian Field–Naturalist* 102(2):304-306 (1988). Notwithstanding the author's statement of the contrary, there is no "verified Canadian record" of this species. The Campobello specimen referred to in the paper was long ago shown to be an overstretched specimen of *Mustela vison* (R. H. Manville. 1966. The extinct sea mink with taxonomic notes. Proceedings of the United States National Museum 122(3584): 1–12).

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Errata: *The Canadian Field–Naturalist* 102(1)

Mongeau, J.-R., P. Dumont, L. Cloutier, and **A.-M. Clément.** 1988. Le statut du Suceur cuivré, *Moxostoma hubbsi*, au Canada. Canadian Field–Naturalist 102(1): 132-139.

Note the following corrections: page 132: left column, line 13: measurent = mesurent; line 14: liage adults = l'age adulte; right column, lines 4-5: caractér-istiques = characté-ristiques; page 133, left column, line 6: recommaitre = reconnaitre; right column, line 4: delete "*Moxostoma hubbsi*"; line 5 reconnaisance = reconnaissance; line 11: Milles = Mille; 16 vain = vains; line 19: Succeur = Suceur; after probablement add: apparu à ; line 24: 1980 = 1986; footnote line 2: preparé = préparé; line 3: ecrivant = écrivant; Monseur = Monsieur; line 4: l'addresse = l'adresse; page 134; Figure 2, caption, line 8: du = de; left column, line 15: démographique = démographiques; right column, line 17: différentes = différents; page 135, left column, line 9: l'éspece = l'espèce; page 136, Figure 4, caption, line 3: dépuis = depuis; right column, line 5: courante = courant; line 10: d'un = d'une; page 137, left column, line 10: l'orde = l'ordre; line 33, associés = associées; cuivre = cuivré; line 34: probabliste = probabiliste; line 41: un = une; line 45: un = une; line 54: nourissent = nourrissent; right column, line 7: Facteur = Facteurs; line 42: générale = général; line 44: d'avantage = davantage; line 50: le = les; page 138, line 13: une = un; line 40: l'exiguité = l'exiguïté; right column, line 6: a = à; line 10: et = , ; line 11: reviser = réviser; line 12: Litérature cité = Littérature citée; line 59: naturalles = naturelles.

ROBERT R. CAMPBELL

Book Reviews

ZOOLOGY

Nature and the Natural Areas in Canada's Capital

By Daniel F. Brunton. 1988. The Ottawa Citizen and the Ottawa Field-Naturalists' Club, Ottawa. 208 pp., Illus. $9.95.

1988 was a very good year for tourism in the nation's capital. It was therefore a most appropriate time for Dan Brunton's guide to be published; a book that will prove most useful for the visitor. Brunton has selected the areas with the most significant natural features that lie within the traditional boundaries of the capital (50 km diameter circle from the Peace Tower.) In all, he describes over 30 locations ranging from riverside marshes to dry interior hills. He gives directions on how to get there; the conditions to be expected (i.e. muddy paths in spring); and any special precautions necessary (i.e. landowners permission required). Each location is shown on a small map and all are located on a regional map.

Brunton starts the book by describing the seven major habitats in the Ottawa area. There is a brief general description followed by an illustrated section on the plants, birds, mammals, and reptiles that are most likely to be found in that area. Forest, meadows, and barrens, farmland, the city, and three types of wetlands are covered.

The species accounts have a small illustration of each species followed by a short paragraph of background information. These notes are not meant as a serious help for identification but are more a brief mix of ecological and historical data. The illustrations come from a wide variety of sources. For example, the bird pictures are black and white versions of Crosby's plates in *Birds of Canada* and the reptiles are from Cook's *Introduction to Canadian Amphibians and Reptiles*. With such disparate origins there is a lot of variability in the style, but the overall quality is good.

The second half of the book gives quite detailed information on each of the most important areas. The maps, all in one style this time, are very clear and easy to follow. Brunton gives a description of the areas ecology and identifies the most probable inhabitants as given in the first section. He also provides some valuable information for visiting the site. This can range from parking through toilet facilities to wheelchair accessibility. In each case the author adds the list of references he has used.

Visitors and newly-converted naturalists will find this book a most useful guide. I would have really appreciated this book when I moved to Ottawa several years ago. Even the dedicated local naturalists will find it valuable for the birders can learn more about plants and vice-versa. A final and very important benefit from buying this book is that the profits go to the Alfred Bog fund. So buy more than one copy. They will make useful gifts and you will contribute to a major conservation effort.

ROY JOHN

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Atlas of the Breeding Birds of Ontario

Compiled by Michael D. Cadman, Paul F. J. Eagles, and Frederick M. Helleiner. 1987. University of Waterloo Press, Waterloo. xx + 617 pp., illus. $53.50 in Canada; U.S. $53.50 elsewhere.

Ontario's first breeding atlas marks a new level in cooperative study by naturalists. The project's two sponsoring organizations, the Federation of Ontario Naturalists and the Long Point Bird Observatory, were joined by 19 additional private and government agencies in providing funding and/ or technical advice. The management committee received advice from six additional committees. The three "coordinators" were really senior editors, who were aided by four additional editors. The 12 paid staff members were aided by an army of 1351 contributors of data cards that represented an estimated 123 879 hours of data collecting, averaging 92 hours per atlasser. Observations collected over the 1981 through 1985 "atlas period" were vetted by regional coordinators representing 46 regions, while the resulting data were summarized in species accounts by no less than 91 authors whose accounts were reviewed by 86 referees. In short, the eight pages of acknowledgements represent a massive volunteer effort.

The book is opened by short descriptions of the two sponsoring organizations, a four-page table of contents, a forward by Management Committee Chairman, J. Bruce Falls, and the acknowledgements. The first 34 pages of text cover a series of introductory chapters. The bulk of the text (pp. 36–565) is comprised of accounts of 298 species and two hybrids. The text is closed with five examples of applications of atlas data. The book is closed with four appendices, a list of plant names, 20 pages of literature cited, and an index of English, French, and scientific names of birds.

The introduction outlines the daunting task of surveying all the breeding birds of the vast 1 068 587 square kilometres that encompass Ontario. Because of the greater accessibility and higher human population of "southern" Ontario (essentially south of a line from Sault Ste. Marie to the Ottawa River near Mattawa), surveys were in 10 by 10 km "squares" there, while all of western Ontario and parts of eastern Ontario north of this line were surveyed in 100 by 100 km "blocks". A 10-page chapter on the biogeography of Ontario provides a good general outline of climate and topography, physiographic regions, forest regions, Ontario's major shorelines, and land-use in relation to their influences on Ontario's breeding avifauna. Missing from this review is any mention of Snyder's 1939 (*Canadian Field-Naturalist* 53: 22–24) plan of Ontario subdivisions and how they relate to the organization of the atlas. Two chapters detail the organization of the "atlassing" effort, coverage goals, methods of data processing, and efforts to ensure that all squares and blocks received adequate coverage. Most did, but one block east of Red Lake lacked any ground coverage, resulting in a conspicuous hole on the maps covering most species that breed there. Four species documented from the air filled a few blanks. The overview chapter of results examines species richness, and provides details of numerous highlights (species recorded in most blocks, species showing expansions of known breeding range, etc.). The final introductory chapter outlines arrangement, terminology and abbreviations.

Species accounts are arranged in three groups, each following the current sequence used by the American Ornithologists' Union. Accounts of 233 species plus the two hybrids (Brewster's and Lawrence's warblers) for which breeding evidence was obtained in southern Ontario each receive a page of text facing a page containing a graph of abundance and maps of breeding evidence. Accounts of 57 species found only in "northern" Ontario follow, each consisting of one page which includes text, a graph of abundance and a map of breeding distribution. Thus, some widespread "northern" species, such as Northern Hawk Owl and various shorebirds, receive less text than "southern" species with very limited distribution (e.g. Summer Tanager) or for which breeding has yet to be demonstrated (e.g. Kentucky Warbler). All species accounts in the southern and northern sections are accompanied by line drawings by 12 artists. These range from mediocre to superb. The final three pages of species accounts are filled with unillustrated accounts of eight additional species, three of which (Brant, Black Guillemot, Bewick's Wren) have nested in Ontario, but not during the atlas period, one of which formerly nested regularly but is now extinct (Passenger Pigeon), and two of which formerly nested but have been extirpated (Trumpeter Swan, Greater Prairie-Chicken). The remaining two accounts cover nesting during the atlas period by a female California Gull with no mate and a male Mountain Bluebird mated to a female Eastern Bluebird.

The species accounts are of more uniformally higher quality than one might expect in a book involving so many authors, even with rigid guidelines to follow. Accounts do vary in degree of documentation from no references at all (Bank Swallow and American Robin) to many. Accounts also vary in their use of other published material on Ontario breeding evidence (nests, breeding bird surveys), but frequent use of such data makes the book even more useful than the atlas data provided. The species accounts are also remarkably free of factual errors of substance.

The final pages of text are devoted to papers describing applications of atlas data: their role in determining relative size of breeding populations; their use in environmental planning; their use in analyzing relationships between crossbills and cone crops; their use in monitoring changes in House Finch distribution in Ontario; and their use in comparing multi-species clusters with habitat features. All these papers enhance the book by providing food for thought for further research. Appendices describe administrative structure, how abundance estimates were made, the process of verifying data, and a list of risk status (as of 1987) of Canadian and Ontario bird species. Problems arising from the establishment of criteria for documentation of rare species after much of the field work was already done should be noted by persons contemplating similar atlas projects elsewhere.

In his foreword, Bruce Falls correctly refers to this book as a snapshot of the breeding distribution of birds in Ontario in the early to mid-1980s. It also provides an indispensable source of information on breeding bird distribution in the province to date, and a quick guide to gaps in our knowledge. As such it should provide plenty of stimulation for further research. It marks a landmark in publication of data gathered through volunteer effort and will serve as a model atlas for others to follow for years to come.

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The Animal Smugglers

By John Nichol. 1987. Facts on File, New York. x + 198 pp., illus. U.S. $23.95.

Everywhere on this planet humankind abuses animals. Evidence of this abuse is documented in a candid, book, *The Animal Smugglers* by John Nichol, which concentrates on the trade in live animals and animal products. The author's underlying goal is to save wild populations. This book will be of great educational and practical value to field naturalists, conservationists, lawmakers, and others interested in wildlife.

The Animal Smugglers exposes the enormous trade in wild animals and animal products, both legal and illegal. It discloses where the animals are caught, how they are caught, their vast numbers, how they are smuggled past international borders, what the markets are, the tremendous profits, and the excessive suffering and cruelty which accompany the trade. For example, birds of paradise are captured in New Guinea and illegally shipped via Java to Hong Kong and Japan, are disguised by a black die and stripped of their long ornamental feathers (which moult and regrow annually), and are included in a consignment of mynahs or crows. Some of these birds land up at very expensive meals, called Mandarin Banquets, where the centrepiece is a complete bird of paradise adorned with its beautiful plumage. At Hong Kong and Macoa, young monkeys (also shipped from Indonesia) sometimes replace the birds of paradise. The point is the display of status, to impress one's guests. During the day of the banquet the monkey is given doses of alcohol. At the meal table, the live monkey is restrained and its head is put through a hole in the table from below so that all that is seen is its head and its chin resting on an appropriate garnish. The skull is then carefully cut off to expose its brain. The guests dip bread sticks, or the like, into its live brain and munch away expressing appreciation to the host, while the monkey blinks solemnly at them — until it dies. In another example, dolphins' eyeballs, selling as souvenirs for a couple of dollars each, are obtained from Brazil; one dealer promises 500 within a week — the death of 250 Amazon River dolphins. Sometimes collectors do conservation work illegally because legislation designed to conserve wildlife is either counter-productive or ineffective. Nichol, himself, does not object to the keeping of animals in captivity by caring, knowledgeable people for the right reasons, such as the breeding of nearly extinct species. He does object to the mass trade of animals, because of the horrific cruelty and losses involved.

The Animal Smugglers points out some of the difficulties involved in protecting wildlife and discourages simplistic solutions. The destruction of habitats and the trade in animal products are even more harmful to wild populations than the trade in live animals. The reasons for these threats to wild populations are 1) no one cares, especially people in the Third World where perceptions are not like those in the West, and 2) the profits from destroying rain forests, from timber, meat, skins, and minerals are astronomical. Governments close their eyes. CITES, the Convention on International Trade in Endangered Species, printed in an appendix of the book, is difficult to enforce even amongst signatories. Nichol is convinced that the only way to save wildlife is to play into the profit motive and to commercialize it; hence, tourist nature reserves run by locals who also get the profits — not by huge hotels — are suggested. Nichol also suggests the abolition of trade in animal products, the keeping of a few specimens for properly-run breeding programs, new laws drafted by people who know what they are talking about (not scientists), the refusal to use paper bags, for example, when shopping, or educating people to realize that pine wood is just as efficient for a coffee table as mahogany. The only way to make the above ideas for saving wildlife work is education. Legislation and changes without education are useless.

The Animal Smugglers is well-researched and well-documented. It incorporates many colour and black-and-white illustrations and follows a clear, narrative-type style. It is also the companion book to a three-part television series seen on National Geographic. The main drawback to this book is its section on North America: it does not say enough about what animal trade goes on *within* the borders of the United States, nor does it cover the Canadian situation where the potential for subversive wildlife abuse is great.

Nonetheless, *The Animal Smugglers* should be valuable to everyone who is interested in wildlife. The exposure of intense cruelty and horrifying losses associated with the profitable mass trade of animals, the revelation of deception and secrecy, and the pointing-out of the complexity of the situation and possible solutions, should sensitize wildlife fans. In fact, the book is a call-to-action, an appeal for the end of this repugnant trade.

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Community and Evolutionary Ecology of North American Stream Fishes

Edited by William J. Matthews and David C. Heins. 1987. University of Oklahoma Press, Norman. viii + 384 pp., illus. U.S. $42.50.

This book contains 31 papers on a wide range of topics subsumed under the title. The papers were given at a symposium held in 1985 and the volume ends with a summary of the symposium. The editors' preface states that "The symposium was designed to provide a forum for presentation of new syntheses or of original research in six areas of stream fish ecology: (1) community dynamics, (2) distributional patterns or faunal alterations, (3) life history strategies and tactics, (4) population biology or genetics, (5) physiological ecology, and (6) functional morphology or ecomorphology. As with most symposia, the papers are a mix of topics and are of varying quality. Some of the papers deal mainly with the author's current research and fail to provide a broader perspective on this theme. Current research papers can be a starting point for an understanding of a field but a review article is definitely better.

Most of the articles are quite short (average of 8 pages each) and some themes were not fully developed in the constraint of a symposium volume. There are papers on ecology in the widest sense of the word, on behaviour, and on systematics but the most interesting ones are those that link disciplines.

R. L. Mayden's paper, for example, describes the historical ecology of highland fishes in eastern North America. An historical perspective to ecology enables the worker to determine whether observed ecologies are purely an environmental phenomenon or are constrained by inheritance. This type of study is in its infancy since the phylogenetic relationships of many taxa are still poorly known. While the study of relationships has seen a renewed interest in recent decades with the development of a rigorous theoretical base, biologists outside systematics still tend to regard this discipline as a nineteenth century pursuit. In his contribution, Mayden has shown that answers to such questions as the age and structure of a community, species associations, ecological traits and shifts, behavioural traits and shifts, host-parasite relations, and adaptive changes need input from phylogenetic studies. R. E. Strauss has also demonstrated the importance of phylogenetics to the study of fish communities. Morphology obviously relates to ecology and can be used to predict habitat use and behaviour. However, not all the variation in fish shape can be related directly to ecological variables, some must be due to the systematic history of members of the community. In addition, as C. B. Renaud and F. Chapleau have pointed out (personal communication, 1988), the recognition of the phylogenetic history of individual species puts a damper on the widespread myth on nature, conveyed by most popular media (T.V., films, books), to the effect that all living species have morphologies that are finely tuned or optimally adapted to their present environment. All species carry with them the weight of their phylogenetic past.

Most of the students of stream fishes in this volume seem to have favoured the pristine environment — and nothing is more pleasant than pottering around in a clear stream — and there is little on the grungy streams which are becoming all too common. Articles by F. B. Cross and R. E. Moss; W. L. Pflieger and T. B. Grace; D. A. Rutherford, A. A. Echelle, and O. E. Maughan; and by H. Boschung assess changes in faunas over time and incidentally support my thesis that systematics and other museum related studies based on collections are important, modern areas of research. Collection records document the loss of species and provide a solid base for determining management procedures which may help the pristine streams to survive our depredations.

The Literature Cited lies at the end of the book instead of at the end of each article, a particularly annoying arrangement and the bane of enthusiastic photocopiers of selected articles. The index does not always work — *Lampetra meridionale* is not to be found on page 218. There is a scientific name index but not a common name index which can make for a confusing read for those not intimately familiar with the diversity of North American freshwater fishes. There are occasional misspellings but not enough to upset the critical eye.

Much of this volume is quite readable, although there is the usual amount of turgid terminology. Despite the editors' preface, most authors correctly use "pattern" instead of the attractive but inappropriate "strategy" (see Chapleau et al. 1988).

This is a most useful book with several stimulating articles. It can be recommended to all those who wish to stray a little from their own highly-specialized field into neighbouring ones.

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The Collins Field Guide to the Birds of West Africa

By W. Serle, G. J. Morel, and W. Hartwig. 1988 (reissue of 1977 edition). Penguin, New York. 351 pp., illus. + plates. U.S. $19.95.

This is not a new book nor is it a revised edition. It is simply a 1977 book being published by a different publisher, namely by the Stephen Greene Press of New York rather than by Collins of Great Britain. No changes have been made to the text or to the illustrations. The only change other than those on the back of the title page is the addition of "Collins" into the title as a reflection of the book's ancestry.

For those not familiar with this book, it falls into the now standard field guide mold. There is an introductory section, in this case four pages which briefly describe the scope of the book and the geographical area it covers. The bulk of the book consists of a phylogenetic listing of 726 write-ups, with each write-up providing the English name, scientific name and brief sections on identification, voice, distribution and habitat, nesting, and for some, a description of allied species. Scattered throughout are a total of 48 full page colour or black-and-white illustrations with the facing page describing field marks. Close to the end is a partially annotated checklist of the 1097 species which have been recorded in West Africa. Following this is a list providing the scientific, English, Spanish, French, and German names for each species covered in the write-ups. At the end are separate scientific and English indices.

As this book remains unchanged from when it was reviewed in Volume 91, Number 4 (October-December, 1977) of The *The Canadian Field-Naturalist*, another substantive review would not be appropriate. Suffice it to say that the criticisms of inappropriate and poor illustrations and textual errors raised in 1977 remain valid. A major drawback of the book is that it only covers 66% of the species which have been recorded in West Africa. Although the authors had hoped that their annotated checklist would go some way towards meeting criticisms of incompleteness (page 11), it does not adequately supply the 34% needed to make the book complete.

Although the book has its flaws and is incomplete, because it remains the only English field guide to West Africa, it is still a necessity for anyone with an interest in the avafauna of that region. This reviewer cannot fathom why copies of the book are being sent out for review. If the intent is to lead unsuspecting people into thinking that the book is a new one, such a ploy deserves any backlash that it might draw.

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Immature Insects

Edited by Frederick W. Stehr. 1987. Kendall/Hunt, Dubuque, Iowa. Volume 1, xiv + 754 pp., illus. U.S. $69.95.

Few references are available for the identification of the immature stages of insects. Keys and descriptions exist for economically important taxa and for many aquatic insects, but often these works are widely scattered in diverse publications. For nearly forty years there has been only one comprehensive work on the immature stages of Nearctic insect larvae, Alvah Peterson's two volume *Larvae of Insects*. This seminal publication went through six editions but is now dated, due at least in part to a great surge in the study of immature insects that the books themselves helped to generate. Like its predecessor, *Immature Insects* is a two volume set, although only the first volume was available for review. Unlike Peterson's books, however, *Immature Insects* is a multiauthor volume. Forty-seven authorities have contributed chapters or sections of chapters to the first volume alone. *Immature Insects* also is more comprehensive than *Larvae of Insects*. Whereas the former treated only holometabolous orders, the latter also treats hemimetabolous orders and the Protura, Collembola, and Diplura. The first volume covers 24 orders including the Lepidoptera and Hymenoptera. The second volume will treat the remaining 10 orders.

The first two chapters provide an overview of terminology, concepts, and methods. Chapter 1, "Introduction," defines the many terms relating to metamorphosis, discusses pupal types (which are not treated in the keys or discussions), and discusses the terms related to larval eyes. Chapter 2, "Techniques for Collecting, Rearing, Preserving, and Studying Immature Insects," is a reasonably thorough treatment of the topics indicated. The section on preservation techniques is excellent. The third chapter is a comprehensive key to the orders of larval insects and certain other arthropods. The key is presented in a nontraditional but highly effective format in which the principal morphological features are highlighted in boldface type followed by the description of the condition in regular type (e.g., **Head:** fused with prothorax). The key is well illustrated, with many of the figures coming from Peterson's books. The figures are labelled but, unfortunately, they are not captioned.

The remaining 24 chapters cover the hemimetabolous orders with the exception of the Hemiptera, Homoptera, and Thysanoptera, and the holometabolous orders Mecoptera, Trichoptera, Lepidoptera, and Hymenoptera.

Although, as might be expected with 47 contributing authors, there is considerable variation in details, each chapter includes an account of the biology, ecology, distribution, and economic importance of the order, a diagnosis and/or morphological description, and a summary classification of the families. Most chapters also include a section on collection, preservation, and study techniques. These sections for the very large order Lepidoptera are quite long and detailed. Each order has a key to the known families of larvae. The keys are followed by descriptions and discussions of each family, comments about unusual species or ones of economic importance, and selected pertinent literature. The chapters on Lepidoptera and Hymenoptera also include keys to selected subfamilies, genera, and species. The keys that I have used have worked exceptionally well.

The book is well written, well organized, and well illustrated. As a textbook or as a reference for professionals, *Immature Insects* is an excellent book. I highly recommend it.

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Of Bears And Man

By Mike Cramond, illustrations by Lissa Calvert. 1987. Fitzhenry and Whiteside, Markham, Ontario. xi + 464 pp., illus. $39.95.

This is another in a line of published works which focuses on that one event which seems to draw the readers to the well: man-bear conflict. The volume is divided into 3 books. Book one, entitled "Men Among Bears", is comprised of 9 chapters and 8 inserts. The 9 chapters focus on people who successfully live and work with bears. For example, Chapters 1-3 concentrate on Dr. Lynn Rogers and his work with Minnesota Black Bears. The 8 inserts are written from the bear's perspective and depict the life of the Black Bear in its environment and with man.

Book 2, entitled "Maulings and Killings", consists of an introduction which briefly outlines 9 fatal encounters with bears and 24 maulings. With the exception of Chapter 8, the remaining twelve chapters are devoted to detailed accounts of the encounters. The author supports his discussion with reprinted letters, newspaper articles, interviews, and information collected during visits to the sites of the encounters. In addition, the recommendations resulting from the inquiries into some of the encounters are included. The inserts in Book 2 depict the life of the Polar Bear, again from the perspective of the bear.

Chapter 8, "How To Stop A Bear", deserves particular attention because the author endeavours to outline techniques which can be employed to deter bears (e.g., chemical, sound, and visual deterrents). In reference to the effectiveness of various deterrents (e.g., airhorns, cracker shells, and chemical sprays) the author states that "there have been studies of the effects of repellents on polar bears, but as with grizzly and black-bear studies, the results are inconclusive". I must disagree with the author. I think it accurate to say that airhorns and cracker shells may work some of the time, but not all of the time, on any of the three species of bears which inhabit the North American continent. Effectiveness of a repellent is a function of many factors, including the experience of the bear, prevailing weather conditions, and surrounding habitat. People who use these deterrents can never be sure of the results until after the bear has reacted to (or completely ignored) the deterrent. Chemical sprays may prove effective; however, researchers are faced with the problem of developing an effective delivery system. I can not imagine a chemical spray working well against a Polar Bear on a windy day along the Arctic coast or a Grizzly Bear on a mountain slope for example, particularly if the person wants to deter the bear at some reasonable distance (e.g., 10-30 m). The spray may serve as a last resort during the onset of an attack.

The work conducted by the various members of the "Safety In Bear Country" program, which was coordinated by the Government of the Northwest Territories, shows promising results. For example, the NWT program researchers have developed and tested a prototype of a nonlethal 12-gauge plastic bullet. Once perfected, these bullets could potentially arm the general public with an effective method of deterring bears at reasonable distance, thus maximizing safety and minimizing the number of bears killed as nuisance animals. Given that this work was initiated in the Churchill area in 1981, and is documented in a number of management reports, I found it disappointing that it was not mentioned in the book.

In addition to deterrent techniques, effective management of man-bear encounters is, in part, contingent upon the development and application of effective detection systems. Researchers with the "Safety In Bear Country" program have identified a number of practical techniques, ranging from a trip-wire system for small tent camps to an infrared detection system for large industrial operations. Detection systems were completely ignored in the book. For a fairly comprehensive account of available detection and deterrent techniques, the reader is referred to Bromley (1985) and Gray and Sutherland (1988).

I was also disappointed in this book because the author virtually ignored the work of Dr. Steven Herrero of the University of Calgary. Dr. Herrero has spent many years studying bear behavior, bear habitat, and man-bear conflicts; he has published extensively on locating and designing hiking trails in bear country, for example. In addition, Dr. Herrero's book *Bear Attacks: Their Causes and Avoidance* is excellent (see *Canadian Field-Naturalist* 101(2): 312–313), and well worth reading.

Book 3, "In Pursuit Of Bears", contains 9 chapters which focus, in large part, on the author's personal experiences with bears from the time he was a young boy growing up in British Columbia. In addition, the author includes more accounts of maulings. The inserts in the last book depict the life of the Grizzly Bear. The epilogue is a short section entitled "Bear Hunting: The Rites And Rights".

Despite its shortcomings, I enjoyed the book, and recommend it to readers interested in man-bear conflicts.

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Herrero. S. 1985. Bear attacks: their causes and avoidance. Winchester Press (Canadian distributor Hurtig, Edmonton). 287 pp.

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Safety in Bear Country: A Reference Manual

By M. Bromley. 1985. Northwest Territories Department of Renewable Resources, Yellowknife. 116 pp., illus.

The potential danger of human-bear interactions has become of increasing interest to researchers, back country travellers, rural residents, northern industrial camps, and others. *Safety in Bear Country* is a manual developed by the Northwest Territories to provide guidelines for dealing with, understanding, and preventing such occurrences.

All three North American bear species are dealt with in a common manner, although it appears that the emphasis, in decreasing order of importance, is on Polar, Grizzly, and Black bears. Given the Northwest Territories origin, the manual is understandably geared towards large expeditions, particularly exploration camps. Nonetheless it provides much useful information for the individual travelling in bear country.

Chapters are succinct but detailed. As an example, thorough descriptions of the general biology of all three bear species, including distribution, annual cycles, size, et cetera, encompass only eight pages; a four-page discussion on behaviour covers social behaviour, dominance heirarchies, and reactions to human encounters. It has been necessary to generalize to cover the most common but not the entire range of behaviour. This may be the biggest fault of the book. There is little room for detailed cause and effect discussions, speculation, discussion of the literature, et cetera. There are few references to specific case histories and the corresponding analysis such as one would find in Herrero's *Bear Attacks: Their Causes and Avoidance*. A few examples of human-bear interactions are appended, but they add little to the manual due to their brevity and lack of analysis.

An excellent chapter on avoiding bear problems provides advice on how to react to several realistic scenarios (e.g. bear unaware of you and feeding, bear aware of you and close, et cetera). Because of the book's brevity, the responses may approach a cookbook style, and cannot anticipate all possible bear reactions. The book's approach of generalizing the responses of all bear species also may not adequately account for interspecific differences.

Several chapters relate to bear avoidance/deterrent procedures including camp layout, bear detection methods, bear deterrent procedures, and firearms. These would be of great value to large industrial camps in Polar Bear range, and include some high-technology solutions (e.g. trip wires, infra-red detection, microwave motion detection systems). They are not very relevant to individuals and small groups.

The manual is well organized in easy-to-reference sections, including index tabs and a three-ring binder format. The binder is presumably to provide for ease in updating the manual, although there is no apparent procedure for doing this. The binder also makes the manual considerably thicker than it would otherwise be if bound at 116 pages. There are ample black-and-white photographs and diagrams distributed throughout the text. The photographs cover most aspects discussed in the text, but their standard small size and variable quality make some subjects difficult to discern. These criticisms may be somewhat unfair, given the obvious intent to provide a valuable and comprehensive manual at low cost.

Safety in Bear Country meets its apparent objective well. It is an excellent reference manual, and should be in the libraries of those working and travelling extensively in bear country. Those who travel in the bush less often would be wise to consult the manual, but they would find much of it inappropriate. This manual should complement other recent books on bear behaviour and attacks. Where the latter describe and analyse, this book will aid in preventing or mitigating human-bear encounters.

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Large Mammals, Volume 2

By Robert E. Wrigley. 1985. Canadian Album Series, Nature Stories for Children. Hyperion Press, Winnipeg, Manitoba. 40 pp., illus. $4.95.

Large Mammals, Volume 2 is comprised of 19 short stories with accompanying line drawings and brief descriptions of classification, morphology, distribution, food, and reproduction. A detailed description of colour is provided for use in colouring sketches.

Each story weaves facts of the animal's life history into a tale depicting an incident or period in its life. The wolverine's habits and habitats, for example, are illustrated in a story beginning with a pack of wolves killing a caribou. The wolverine finds the cached remains on which it feeds for several days. When the wolves return the wolverine stands them off and, though wounded, is victorious in keeping the prize.

The stories are quite effective in portraying the animal's place in the ecosystem. The composition sparks the imagination, although the vocabulary is often much too difficult for young readers and listeners to comprehend. There is some ascribing of human traits to the animals, but not in a Disneylike manner. Atlantic White-sided Dolphins reunited with a family member are jubilant. They "remembered each other over the long period of separation". This technique does not make the stories read as fantasy, rather it makes the characteristics more clearly understood by children.

The descriptions of distribution, food habits, et cetera, for each animal are brief and useful for those wanting more scientific information. Noticeably lacking are scientific names.

The drawings are well placed opposite each story. They are "adaptations of original watercolour paintings by Canadian wildlife artist, Dwayne Harty". The colouring is sometimes complex for younger children. Others such as a Polar bear on ice floes or a fisher in forest understory give little variety for children to colour. Older children may not be interested in colouring any more, although the challenge of matching the animal to the described colours may be acceptable.

This book is useful as an introduction to the variety of large mammals in Canada. The series could be a good one to have in classrooms of almost any grade school level. Teachers or parents will need to explain many words to primary age children, and senior grades might find the story format too simple to enjoy. The book is probably most useful for children in Grades 2 to 6. An adult and other resources to supply more information could promote a keen interest in Canadian nature for young people. This series helps fill the apparent lack of science materials, especially in biology, available in grade schools. Parents will find the stories make good family reading, and they'll likely learn along with the kids.

I would recommend the book to any children from 5 to 12 years old, with the understanding that adult assistance is needed for the younger children. The series would make a useful addition to a family's nature guides.

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Tufted Ducks in a Royal Park

By Eric Gillham. 1986. Published by the author and available from 31 Coast Drive, Romney Marsh, Kent, TN29 9NL, U.K. 308 pp., illus. £20.00.

Rosamond's Pond was enclosed in 1593 in the (then) countryside outside the City of London, and was stocked with fish and waterfowl — a "living larder" to provide fresh food in winter. The pond was incorporated into the new St. James's Royal Park in 1602. There have been waterfowl in the park ever since, and one species that has lived there for 300 years, unpinioned, is the subject of this book.

The Tufted Duck, *Aythya fuligula*, is related to the North American Ring-necked Duck and the Greater and Lesser Scaup. It breeds freely in some of London's innermost public parks and the data in the 43 tables and 13 appendices were gathered in St. James Park. It says a great deal about the British public and the adaptability of the bird that the ducks survive and breed in the heart of London.

This book will appeal more to a duck specialist than to the average naturalist. It is neither a full scientific study, being a mixture of the specific and the general, nor is it an ecological study. But there are interesting detailed descriptions of courting behaviour, plumage, nesting, rearing of young, and feeding habits of the Tufted Duck and some hybrids. Conditions in the Park are hardly comparable to a wild habitat, of course. For one thing, man-made nesting structures and supplementary food are available, and predators are controlled. Some of Eric Gillham's records cover a period of thirty years to 1984. The time span of his study therefore gives an unusually long and valuable perspective: for example, it documents weather influences on fledging success, and long-term population fluctuations. Judging by Appendix 13, birders visiting London could spend a profitable hour or two in any of the parks: the 1984 list for St. James's shows 106 species of birds, of which 41 are pinioned ornamental waterfowl such as Chiloé Wigeon, and Bar-headed Geese. The rest are wild visitors.

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The Natural History of Whales and Dolphins

By Peter G. H. Evans. 1987. Facts on File, New York, New York, 343 pp., illus. U.S. $21.95; $29.95 in Canada.

This book was waiting for me when I returned from a whale-watching trip in New Brunswick. The trip had been somewhat disappointing as we endured a lot of late season fog. But whale-watching is always an uncertain venture. They are animals who live largely out of sight, in a vast, apparently uniform habitat, and in many cases have very small populations. These problems are evident in this book. The author has compiled the data we have on these elusive creatures into one compact volume. But there are enormous and tantalizing gaps in our knowledge which would require endless months of patient research to fill.

The author intends this book to introduce the reader to the ecology and behavior of whales and dolphins. It is not meant as a coffee table delight, a romantic treatise, or a field guide, but to satisfy the curiosity of the keen naturalist.

The chapter on classification does give identification information but it is too spartan to be of use as a guide. Indeed the author suggests using the *Sierra Club Handbook* (S. Leatherwood and R. Reeves, Sierra Club Books, San Francisco, California); there are several other choices available. The classification given is more recent then these guides and, while sparse, is useful and completes the book.

The most interesting chapters for me were on evolution and social organization and behavior. The fossil record for all animals is meagre and discontinuous. This is particularly true of the whale's ancestors. With such an erratic data set, the author has had to be careful in his choice of potential theories and where, in places, to enter the realm of speculative science. The result is interesting reading with many thought provoking ideas.

Their social organization and behavior are perhaps what sets these animals apart. Whales are an extraordinarily complex and heterogeneous group with each species having quite different social structures. The author has tried to show how these structures and behavior patterns have helped ensure the species survival. Also, he discusses how the unparalleled slaughter of recent times has changed those age-old patterns. I liked the authors treatment of altruistic behavior, which was sympathetic but mercifully unpatronizing.

Other chapters cover distribution, food and feeding, systematics, zoogeography, and life histories from reproduction to mortality. The three final chapters are on man's impact on whales. A short but thorough history, from the earliest times of recorded history to the present day machinations of the last major whaling nations, puts the slaughter into a clear perspective. The last two chapters discuss the current situation. Subsistence whaling and its importance to "primitive" cultures is given an honest and logical treatment. The book finishes on a more positive note. It outlines the type of scientific work being done using the latest tracking devices, which should provide a better understanding without the need to kill.

The author, in my opinion, has indeed achieved his objective and produced a concise, up-to-date natural history of whales and dolphins for the enthusiastic amateur. It makes both good reading and a good reference. It is well illustrated with maps, and black-and-white drawings. There is a small, but excellent, collection of colour photographs. The writing is fluid and avoids the unnecessary use of scientific terms, important in a book intended for the more popular market. Let us hope the author and his scientific colleagues around the world can continue their work and that more books like this one will result, providing a happier and more complete understanding of the worlds largest and most enigmatic creatures.

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Sea Snakes

By Harold Heatwole. 1987. New South Wales University Press, Kensington, NSW, Australia. viii + 85 pp., illus. A $12.95.

To herpetologists, a review of "sea snakes" would probably be restricted to the venomous, tropical, marine "cobras". However, in considering all forms of snakes that live in marine, saltmarsh, and estuarine environments, this popularized review of the biology of "sea snakes" fulfills the goal of promoting education and research (in Australia) to all levels of government and the media. And because this review pulls together information on the biology of all forms of snakes that live in salt water, it synthesizes much about the biological requirements and adaptations of snakes in general to the marine environment. Consequently, Heatwole far surpasses the goal of the book by synthesizing and disseminating technical information in lay terms, making it easily understood by those unfamiliar with the often unwielding vocabulary so familiar to science.

The sea snakes surveyed in the review include the "true sea snakes" (family Hydrophiidae), "sea kraits" (Laticaudidae), two subfamilies of "colubrids" (Colubridae), the homolapsines and natricines, and the "file snakes" (Acrochordidae). The splitting of the true sea snakes and sea kraits as separate families is controversial and probably unwarranted. There is no doubt that these snakes were derived from within the family Elapidae; the salient question is whether or not these snakes form a monophyletic lineage, i.e., if they shared a most recent common ancestor exclusive of all other elapid snakes. At most the two groups should be allocated to separate subfamilies within the family Elapidae. Regarding the age of the snakes, much reliance is placed upon fossil information. As noted by Heatwole, snake fossils date back to 135 million years ago. Because no pre-Oligocene fossils are known from modern terrestrial (colubrid) snakes, he assumes that the first snake lineage became extinct after 100 million years and that all modern terrestrial colubrid snakes and their derivatives have evolved during the past 35 MY. Although the recent age of colubrid, elapid, and viperid snakes may only be 35 MY, the absence of fossil data provides only "negative evidence" for such a recent divergence and as such should be treated with great skepticism.

Most of the data presented in the book deal with the venomous sea snakes simply because we know more about these groups. Notwithstanding, some very valuable comparisons are made, mostly with the file snakes, thus providing the comparative approach to biology. Each of the five chapters is logically organized and contains clear subheadings. The chapters provide a generally thorough coverage including diversity and distribution, natural history, physiological ecology, venom, and interactions with humans.

As is typical of any good review and synthesis, Heatwole offers some new significant interpretations and criticisms of published research. He frequently points to critical areas where carefully designed experiments are required to resolve conflicting interpretations of observations and data. The beginning student would do well to follow carefully the clearly laid out questioning of "established" ideas.

The figures are clear and easily interpreted, except for two reproduced photographs. Overall the quality of production is good, especially considering the cost. There are a few typographical errors but these are not critical, except for the occasional incorrect spelling of taxonomic names, such as "Anomalopheidae" which should read Anomalopheiidae, or the interchange of Typhlopidae and Typhlopoidae in Figure 1.1.

Overall, the work can only be summed up as being excellent. The serious herpetologist may be frustrated only by the lack of in-text references and the very short bibliography, but this obviously results from the semi-technical nature of the book. The lack of citations is somewhat annoying since the only other volume on sea snakes (W. Dunson. *Editor*. 1975. *The Biology of Sea Snakes*. University Park Press) is now out of print and becoming difficult to find. Nevertheless, anyone who is mildly interested in the biology of snakes, general oceanography, or in the adaptation of animals to the marine environment will find the work to be of great interest and value, and easy to read.

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Animals of the Western Rangelands

By Ernest H. Elms. 1986. Naturegraph Publishers, Happy Camp, California. 220 pp., illus. U.S. $8.95 + U.S. $1 postage.

In my first few minutes of reading this book I wondered why anyone would bother to publish such general material about so limited a selection of animals, and I put the book down to think about how to review it. Days later, when this review was partly done, the answer came. The problem was me, not the book. I had fallen into the trap open to most people with special knowledge when they forget that their narrow specializations are unusual in a world filled with beginners, for even world leaders in fields of knowledge are beginners in hundreds of other fields. Books like this are needed to start people into collecting special knowledge.

Here is a readable, "downhome" account of some animals living on the federally owned rangelands of the western United States. This is no guidebook, but a collection of 31 essays, each dealing with an animal's natural history — its habitat, food, reproduction, "enemies", abundance, and general behaviour. The writing style is popular with information packed into every paragraph. Some general statements could stand support from inclusions of sources ("Did he really see this? If not who did?"), but otherwise it is a good read and would be just right for beginners living in or visiting the dry cow-country in the mountainous west.

The animals in the book are a curious assortment of 22 mammals, six birds, and one each of an insect, an amphibian, and a reptile, the last three being the dragonfly, spadefoot toad, and desert tortoise. Birds included are all large, ranging in size from Trumpeter Swan to Burrowing Owl. Mammals go in size from buffalo and wild horse down to kangaroo rat and pocket gopher, but are predominantly the largest ones possible. Most ungulates are present as a result. The one common factor in most animals included is their habitat preference for grassland or adjacent dry and grassy forest, which perhaps explains the absence of White-tailed Deer since it favours the moister valley bottomlands. This, however, fails to explain the presence of "the dragonfly" which is aquatic for most of its life. Maybe the author just included those animals he knew.

A few errors surfaced through my quick read. These embarrassments can hide from authors in popular writing that is solid with information, hard to find because they surface as misinformation although long held in the memory as fact. The more obvious errors found involve the geography of Elk and Trumpeter Swans. The "Roosevelt" Elk living on the coast of British Columbia are not transplants from the south as stated, but are Canadian natives that lived there long before Europeans invaded the Americas; and the Trumpeter Swan was not saved from extinction in a wildlife refuge in Montana, popular as that myth may be, for at its lowest ebb survivors were breeding in Alaska and British Columbia, perhaps also in Yukon, Northwest Territories, and Alberta.

Contents of this book are perhaps best described as animal lore by a careful outdoor writer. It will give those newly interested in natural history and ecology a basic understanding of the lives and times of the more evident animals found in the far west where there is still wild rangeland. In my school days I enjoyed many such books of essays about regional animals. They gave me not just good reading, but memorable information and day dreams which changed my life.

We need more books like this. They awaken urban minds to the wild and living world that is by far our most important heritage.

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Treasury of North American Birdlore

Edited by Paul S. Eriksson, and Alan Pistorius. 1987. Chicago Review Press (Canadian distributor Beaverbooks, Markham). 338 pp., illus. $28.95.

Discussions of man's continuing fascination with birds, particularly the birds of this continent, from the days of the early naturalist writers exploring a new land to today's scientific findings by trained ornithologists, are all to be found in this anthology of 88 readable essays.

With its extraordinary range and comprehensiveness, this book is an excellent introduction to the study and appreciation of North American birds.

The book is many faceted. One section deals with the key questions about birds as living organisms, as in Christopher Leahy's essay on birdsong. In this piece Leahy points out that as a class, birds are perhaps the most vocal of animals. "The majority of species have an elaborate vocabulary equaled by only a few gregarious mammals and conspicuously surpassed only by ourselves.

"Anyone who has paid any attention to the sounds birds make is aware of two broad categories of vocalization". In addition to the territorial/signal song containing a series of notes uttered in cohesive sequence so that they form a characteristic phrase with a recognizable rhythm and "tune" like a line of music, there's another type of song that seems to be unrelated to the breeding cycle. This type of song, Leahy says, seems to be a pure release of energy of the kind that Shelley attributed to his Skylark. These "emotional-release songs" usually happen at random and may be accompanied by an "ectasy flight". "But even sober scientists, who eschew anthropomorphism by profession, acknowledge its expressive quality and have even suggested that it contains a germ of artistic invention(!)."

Then there's a section of essays exploring the private lives of birds, such as John Muir's essay on The American Dipper. Muir, of course, was an early naturalist writer, who unlike many naturalists today, saw no reason why he should strive for objectivity. His emotions are plain in his description of the dipper, or ouzel as it was then called and to me, at least, add a whole other dimension to a remarkable species.

Muir calls the dipper "a singularly joyous and lovable little fellow, about the same size as a robin, clad in plain waterproof suit of bluish gray, with a tinge of chocolate on the head and shoulders. In form he is about as smoothly plump and compact as a pebble that has been whirled in a pot-hole, the flowing contour of his body being interrupted only by his strong feet and bill, the crisp wingtips and the up-slanted wren-like tail."

Describing the song of the dipper or ouzel, who "must sing though the heavens fall," he says "nearly all his music is sweet and tender, lapsing from his round breast like water over the smooth lip of a pool, then breaking farther on into a sparkling foam of melodious notes, which glow with subdued enthusiasm, yet without expressing much of the strong, gushing ecstasy of the bobolink or skylark."

This is also a book about people and their involvement with birds. We get a quick look at a meeting between Alexander Wilson, who was writing the first work on American birds and John James Audubon, then an obscure merchant in Louisville, Kentucky. Audubon refused to subscribe to Wilson's work. Wilson, who until that moment felt safe in the uniqueness of his enterprise, was stunned when he saw Audubon's drawings which 20 years later were published in the famous Birds of America "Elephant Folios" and tended to overshadow Wilson's work.

There are stories like Frank M. Chapman's vintage piece on Hat Birds in the Haute Monde. Written over a hundred years ago this should be of interest to naturalists as the scene he describes, notebook in hand at the corner of Fourteenth Avenue in New York City, is hardly likely to be repeated today. Listing many familiar birds such as bluebirds and scarlet tanagers, he writes that "it is probable that few if any of the women whose headgear formed part of my record, knew that they were wearing the plumage of the birds of our gardens, orchards, and forests."

This volume speaks in a rich variety of moods and voices touching on the whole spectrum of the world of birds. Tightly edited, the editors have indeed included, as they planned, essays informative and celebratory, momentous and lighthearted, quiet and dramatic, hopeful and melancholy, contemplative and adventuresome.

First issued in 1962 (Doubleday) as *A Treasury of Birdlore*, this newly revised, updated 25-Anniversary edition with more than 30 new selections, including one by Walt Whitman is surely one most naturalists will want to add to their bookshelf.

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Dragonflies

By P. L. Miller. Cambridge University Press, New York. 84 pp. U.S. $24.95.

This slim volume is the seventh in a series on entomological topics that has been published by Cambridge University Press over the last few years. Like the preceding volumes in the series, this one has also been geared towards students, but is likely to be of benefit to the serious naturalist as well.

The book is divided into two sections, the first of which deals with the biology of dragonflies (the authors use the term in its broad sense to cover both dragonflies and damselflies). The latter part of the book is devoted to keys to the British species.

The keys are clear and well illustrated and include, in addition to the line drawings, four beautiful colour plates. Both larvae and adults are keyed to species, but the use of these keys is limited to the British fauna and fully one third of the volume remains of little use beyond those geographic limits.

The extensive biology section is more generally applicable, though most of the examples are also drawn from the British fauna. The subjects covered in this section range from development and physiology through to behaviour, reproduction (considered in terms of both physiology and behaviour), and ecology. Each of these chapters usually also contains some practical experiments, some of which can be performed with very little specialized equipment. All of these are designed such that the reader could observe, first-hand, some of the processes described in the text (e.g. flight can be observed by attaching the adult to a wire with sealing wax). The book also contains practical information on observing, collecting, and rearing dragonflies.

All of this information has been presented by the author in a clearly explained manner, using straightforward examples. Where possible, these have been illustrated with line drawings to aid in understanding the mechanisms.

The book is well aimed at the naturalist, whether student or amateur. For the former, the author has also attempted to identify those areas where questions remain unanswered and research might produce productive results. For the latter, the book is a wealth of information about dragonfly ecology and biology. It should serve to heighten the readers awareness of what exactly they are seeing the next time they stand by a pond or stream, watching these remarkable insects.

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BOTANY

Flora of New Brunswick

By Harold R. Hinds. 1986. Primrose Press, c/o Mr. H. R. Hinds, Biology Department, University of New Brunswick, Fredericton. xxvi + 886 pp., illus. $30.

Harold R. Hinds has produced a very compact, soft-covered vascular flora of New Brunswick. The cover has an illustration of Canada's rare *Pedicularis furbishae*, one of Dr. C. Mary Young's illustrations, others of which are included in the illustrated glossary. The book exceeds the original objective by including 206 pages of appendix with plant illustrations by Carol Bayley, and distribution maps. This was a very useful and pleasant surprise for people who saw the work in progress, in the botany labs at Fredericton, in the late 1970s and early 1980s.

The introduction includes notes on how to use the book, location of New Brunswick, physiography, glacial history, climate, and a history of plant collecting, followed by acknowledgements. All taxa are keyed with numbered unindented keys and for each, common name, frequency, habitat, general range, and notes are included. The main text (424 pages) is followed by a page of "references cited", a nicely illustrated glossary (8 pages) and a 26-page index. The names are based largely on the list in Kartesz and Kartesz (1980), and the order of plant families basically follows the Engler and Prantl system beginning with fern allies and concluding with the Aster family. The distribution maps, slightly larger than postage stamp size, represent 1032 taxa (mostly species). Many widely distributed species are not mapped nor are a number of rare species that have been found only a few times. The appendix of distribution maps includes 85 pages and the preceding appendix of illustrations (also slightly larger than postage stamp size) includes 122 pages and 1437 taxa.

The book is quite portable, only 23 × 15 × 3.24 cm, weighing 900 grams and is bound in fascicles with a plasticized cover for extra durability. The text is photoreproduced from word-processed pages, and the layout is pleasing given the constraints of the process and cost.

Even a very comprehensive work, like *Flora of New Brunswick*, is not likely to be devoid of errors or opportunities for improvement. A listing of corrections is available (from Hinds). Indented dichotomous keys would have been easier to use and the placement of the index at the very end would also have improved utility. A map identifying major geographical features and towns was not included. The treatment of *Juncus dudleyi* as *J. tenuis* var. *uniflorus* is an inadequately documented departure from most recent taxonomic treatments and *J. dudleyi* does not appear on p. 130 as the index suggests. *Juncus interior* is illustrated on page A36 but does not appear in the index or the key and following text. *Typha* × *glauca* Godr. could have been included in the key to facilitate identification. Only the treatment of *Atriplex* was contributed by a specialist (Pierre Taschereau), the remainder of the work being done by Hinds. It is clear that in developing his treatments of various groups, Hinds used recent papers published in various scientific journals and if he had made reference to these it would have increased the value of the work substantially. The only references provided are on a single page, and these must represent a very small percentage of those used. The absence of a complete list of references concerning floristics in New Brunswick is not serious because these do not serve to explain taxonomic treatments and a listing to 1985 is available in Agriculture Canada Publication 1986-3E, at no cost. With regard to the illustrations, some do not portray diagnostic features used in the key, such as those of *Elodea nuttallii* and *E. canadensis* and the characteristic tailed seeds of *J. vaseyi* are not shown. There are a number of such examples of errors or opportunities for improvement, but given the volume and general accuracy of the work, they do not assume much importance.

The stated purpose of *Flora of New Brunswick* is "to provide a means of identifying all of the vascular plants growing without cultivation in New Brunswick." It succeeds excellently. Information is readily obtained from the text because of the use of boldface and subheadings. The keys are easy to use, sometimes in conjunction with the well-illustrated glossary, and some keys incorporate novel character combinations and represent improvements over existing keys. The illustrations are generally very good and very useful, and the distribution base maps are clear and accurate. *Flora of New Brunswick* is by no means a simple compilation of existing data. It also represents many hundreds of hours of field work and careful study on the part of the author. It is a very substantial contribution to North American systematics and to the flora of Canada and it is very, very reasonably priced considering its content. This book was preceded by Hind's *Flora of Cape Cod,* his *Trees and Shrubs of New Brunswick* and *The Rare Vascular Plants of New Brunswick*.

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The Asters of Ontario: *Aster* L. and *Virgulus* Raf. (Compositae: Astereae)

By John C. Semple and Stephen B. Heard. 1987. University of Waterloo Biology Series No. 30. 88 pp., illus.

The asters have always been notoriously difficult to classify and identify. The plants included in this regional monograph have generally been placed in the single genus *Aster*, until recently. Although many botanists may have an aversion to splitting a genus that they thought they could recognize, the evidence for separating *Virgulus* from *Aster* seems to be solid. It is unfortunate that the authors did not devote a bit more space to the justification of this split; there is only a limited general discussion of this issue in the introduction. Admittedly, this booklet is aimed at a competent but non-professional audience, but splitting such a "well known" genus requires more than a brief comment. After reading some of the primary literature on the subject (e.g. J. C. Semple and L. Brouillet. 1980. *American Journal of Botany* 67: 1010-1026), I am willing to accept their conclusions.

There are a few additional taxonomic changes that Ontario botanists will have to become familiar with (e.g. *A. azureus* must now be called *A. oolentangiensis*, and *A. sagittifolius* must be called *A. urophyllus*). Such changes serve to indicate the dynamic state of systematic botany. It is important that organism-based research continue, in spite of the declining interest and support from granting agencies, not only so that we can apply the correct names to organisms, but more importantly, so that we can learn more about, and draw relevant conclusions from, our environment and its component species. Although an important function of a monograph such as this is to summarize the current state of knowledge, it can also serve to focus our attention on what *isn't* known. Here are a couple of questions that come to mind after reading this book: Why does the hybrid, *A. X blakei*, occur in Algonquin Provincial Park, when one of its parents (*A. acuminatus*) is not known there? What ecological (or other) factors account for the absence (disjunction) of species like *A. urophyllus* along the north shore of Lake Ontario?

The key, species accounts, maps, and illustrations comprise the body of this monograph. Based on my field experience with many of these species, I feel that the illustrations capture the essence of the species very well. Another useful feature of some of the illustrations is the depiction of extremes or variants. The key appears to be quite workable and easy to use. The authors have attempted to be as up-to-date as possible in representing the distributions of Ontario's asters, as a comparison of the maps in the *Atlas of the Rare Vascular Plants of Ontario* (1983) and in this publication indicates. This also indicates that collecting efforts on the part of active field botanists can have a significant impact on our knowledge of the distribution and spread of plants.

My only criticisms of the *Asters of Ontario* have nothing to do with content. This book has been produced on a word-processor into camera-ready copy, which is fine. However, there are several typographical and other copy errors (at least 14), indicating that not enough care was taken in the proof-reading. The other problem is cosmetic. The italic print is quite faint unless it has been bold-faced. These problems should not deter anyone from using the book — the contents are the important thing!

The asters of Ontario should become much less difficult to deal with, now that this publication is available.

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Major Habitat Types, Community Types, and Plant Communities in the Rocky Mountains

By Robert R. Alexander. 1985. General Technical Report RM-123. United States Department of Agriculture, Forest Service, Fort Collins, Colorado. 105 pp. No charge.

Mountain systems provide an extremely wide array of ecological conditions in which plants may grow, due to variation in altitude, substrate, geological and geomorphological history, exposure, and factors correlated with latitude. The Rocky Mountains, although less complex than some other major mountain systems of the world, are no exception. This report summarizes, in tabular form, a large amount of qualitative data on the forest types found in the American portion of the Rockies.

A brief introductory section serves to define the ecological terminology used in the tables. The somewhat archaic concept of "climax" is central to this discussion, but at least several types of "climax" are admitted. These include primary, edaphic, climatic, and topographic climaxes, which provide quite a bit of flexibility to deal with local site conditions. The major trees dealt with in this report, *Pinus ponderosa, Pseudotsuga menziesii, Abies concolor, Picea pungens, Populus tremuloides, Pinus contorta, Picea engelmannii,* and *Abies lasiocarpa*, may also be considered seral in some types of communities, where disturbance has occurred. The vegatation classification scheme begins with the "series", which is comprised of all plant associations containing the same overstory dominants. It is assumed that macroclimate is more important than microclimate or edaphic factors for the dominant tree species. However, no data or references are presented to justify this contention.

Understory vegetation is used to subdivide the "series" into a large number of "unions". These are thought to be dependent on microenvironmental conditions, which again, may well be true, but there is certainly evidence in the literature that suggests that stochastic effects cannot be ignored. This unpredictability of recruitment of species (or at least of numbers of individuals, and hence, importance of a species) in the understory limits the usefulness of this level of classification, especially if the splitting is excessive, as I think it is in this case. There are a couple of additional categories used to classify species associations that don't fit into the "series-union" scheme. These are "community types" and "plant communities". The distinction between these is not meant to be ecological, but rather methodological.

In spite of the problems with ecological concepts and the lack of any references to current systems-based primary literature, the tables may be useful in a general way, in providing the reader with a feeling for the site conditions, distribution, and major associates of the dominant tree species in the Rocky Mountains of the U.S.A. But what about non-treed communities? Mountains have alpine areas where trees don't occur, and there are wetlands, too! The title of this publication is misleading, because the implication is that the whole spectrum of community types will be dealt with (or is "major" synonymous with "tree"?).

Part of the problem is that there is no discussion of who is the target audience for this publication. I presume that it is intended for foresters, land use planners, and managers. There isn't enough background discussion, or analysis, for it to be aimed at ecologists. I am surprised by the lack of context that is provided in the discussion. For example, how does the work of V. Krajina in the British Columbian Rockies compare with the American classification scheme? If two different approaches to vegetation classification arrive at similar conclusions, then more confidence can be placed in the scheme, but we aren't told in this publication.

I suspect that this publication has pragmatic aims, and is not intended to be analytical; but the author should have said so. There is a lot of qualitative information in this report, and it provides an initial summary of what is known, but now it is time to ask (and try to answer) questions about what makes natural plant associations in the mountains tick!

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Poisonous Mushrooms of Canada

By Joseph F. Ammirati, James A. Traquair, and Paul A. Horgen. 1985. Research Branch, Agriculture Canada Monograph 30. Fitzhenry and Whiteside, Markham, Ontario. xxiii + 416 pp., illus. $75.

This book presents an unusual approach to mushroom study. It appears at first to be a conventional field guide to mushrooms and to differ little from a number of others. The difference is that while nearly all of the others concentrate on edible mushrooms this one is limited entirely to poisonous ones.

It begins as many other mushroom guides begin, with chapters on the macro- and microscopic structure of mushrooms and other fungi. Included in this part is some information on the natural occurrence of mushrooms, including natural habitats and seasonality. The first part concludes with a disscussion on the taxonomy of mushrooms and related fungi. An extensive series of identification keys is provided that cover most genera of mushrooms and other fleshy fungi occurring in Canada.

The second part of the book deals with mushroom poisoning. It begins with an overview and a classification of seven distinct types of fungal poisoning and a comparison of some species of edible mushrooms with similar poisonous ones. The main section of this part (and the book) consists of discussions of toxicology, symptomology, and detailed descriptions, illustrations (many in colour), and discussions of poisonous species known or suspected to occur in Canada. This section is organized according to the seven types of poisonings defined previously so that they may be sought by the symptoms of the poisoning they have caused.

The book ends with a list of the specific mushroom specimens used in the descriptive part of the book, followed by a glossary of technical terms and an index.

One supposes that the principal users of this book will be those who must deal with cases of mushroom poisoning. In Ontario the usual sequence of events following a suspected poisoning is that the victim telephones his or her physician or goes to a local hospital emergency ward. The physician or other person dealing with the patient then calls a poison control or information centre, often in another city, which in turn contacts a specialist in mushroom identification. The specialist can then examine the mushroom and report to the centre or attending physician. If the species of mushroom is determined, treatment will be according to the type of toxin known to occur in that species. Only rarely will medical personnel attempt to identify a mushroom. Thus in cases of actual poisonings the principal users of this book will be professional mycologists or people with experience in identifying mushrooms.

As a professional mycologist frequently concerned with cases of mushroom poisoning, I find this book to be very helpful and refer to it frequently. It is well organized and allows me to find the offending species with little difficulty. I especially appreciate the grouping of species by the type of poisoning they cause because that is often the first and most accurate kind of information a physician can give me. The microscopic features of the species are well illustrated and described, an important matter when the specimen available may be little more than fragments from the patient's stomach.

This book is clearly indispensible to the consulting mycologist; but who else might use it? Much of the introductory material is written for the uninitiated and would seem more at home in a field guide or textbook. I doubt that many medical people will use it extensively although it would be helpful to have it in a poison control centre library. Most general collectors of mushrooms in Canada are searching for ones to eat and will be disappointed to find only inedible species in this book. It may appeal to a smaller group of mushroom enthusiasts who have graduated beyond the stage of regarding mushrooms only as items of food, but it is limited only to those species known to be poisonous and thus may be found to be too restricted in scope. However, there is much here that will not be found in any other book of its kind; the coloured photographs of nearly all the species are excellent and anyone seriously interested in mushrooms would want to have it.

In summary, this is an excellent text that is proving to be the standard reference for identifying poisonous mushroom species. It is an essential part of the library of mycologists consulted in cases of suspected mushroom poisoning. It should be in the libraries of hospital emergency centres and will be of interest to anyone who wants to learn more about mushroom poisoning and the species that cause it.

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A Handbook of the Mexican Roadside Flora

By Charles T. Mason and Patricia B. Mason. University of Arizona Press, Tucson. 380 pp., illus. U.S. $19.95.

This is a most welcome publication. The only flora which covers Mexico is Hemsley's monumental five volume *Biologia centrali-america* which is now a hundred years old, and rather too cumbersome for all but the most dedicated botanizing tourist. The present work is aimed at the amateur, but is quite useful to the botanist on holiday amid an unfamiliar flora. The contents include a brief section on the geography and vegetation of Mexico, a diagnostic key to families (and in some cases tribes or genera), species descriptions, and a glossary of terms. The key is straightforward and easy to use; each couplet is prefixed by the number of the couplet which leads into it; quite handy since the key is 12 pages long.

Families, and genera and species within families, are arranged alphabetically. More than 200 species are treated. These were chosen, according to the authors, because of conspicuousness — showy flowers, unusual fruit, attractive foliage, or overall abundance. Choices were based on experience with inquiries from tourists returning home from Mexico. Plants included are those to be seen on major roads, and around hotels and motels. A few choices (e.g. oleander and poinsettia) seem like a waste of space, but for the most part the selection is good. Each entry, in addition to a description of the plant, includes notes on its natural history, origin, and economic use. The line drawings by Patricia Mason are very useful.

The last time I was in Mexico (more than 25 years ago), my interests were primarily archaeological rather than botanical, but for those species or families with which I am familiar from the Californian, Caribbean, or South Asian floras, the illustrations were immediately recognizable. This book will definitely accompany me on a planned trip to Mexico.

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ENVIRONMENT

Sustainable Development of the Biosphere

Edited by William C. Clark and R. E. Munn. 1987. Cambridge University Press, New York. 491 pp., illus. Cloth U.S. $49.50; paper U.S. $17.95.

Seventeen overview papers on the sustainable development of the biosphere are compiled in this book. These papers were presented in August 1986 at a task force meeting held at the International Institute of Applied Systems Analysis (IIASA) in Laxenburg, Austria. This meeting was held to elaborate the ideas behind an IIASA feasibility study on sustainable development of the biosphere. The purposes for this study included consolidating our understanding of global ecological and geophysical systems, analyzing how global environmental change could inhibit regional development, and suggesting improved institutional and organizational designs for more efficient resolution of environmental problems. These task force papers made admirable progress toward these goals.

The papers were presented by prestigious workers in ecology, environmental history, climatology, hydrometeorology, atmospheric chemistry, agriculture, forestry, fisheries, economics, public policy, sociology, nuclear energy, statistics, and environmental law. The papers are divided into four parts: human development, world environment, social response, and usable knowledge. Each paper is followed by expert commentary.

Not all environmental problems were covered in detail. Little space was given to endangered species, water quality, and soil erosion. However, the most alarming global environmental problems such as global warming, ozone depletion, and acid deposition were given considerable attention. Other related global issues covered were desertification, ecosystem stability, energy development, agricultural development, and sustainable yield from fisheries and forests.

In a book titled *Sustainable Development of the Biosphere*, I expected to find examples of sustainable development. Sustainable development may be another idyllic goal that is strived for but never reached due to the rapid changes that are occurring in the demand for various natural resources. Our characterization of the sustainable development of a particular resource changes over time with the advancement of technology. Often our minimum standards of acceptance of a resource drop as that resource declines in quality with continued exploitation. Advancements in technology permit us to utilize resources of lower and lower quality.

An excellent discussion of the history of the forest industry in New Brunswick by Gordon Baskerville illustrates this point. This industry started in the 1700s with the selective cutting of very large white pine for ship masts. Once these became too scarce, smaller white pine were cut for squared timbers to be used in construction. By the mid 1800s, the sawmill industry developed. This industry accepted the remaining white pine and larger white spruce. This industry grew faster than the rate at which the forest could produce trees of the desired species and size. As a result, the sawmill industry has been in decline since the turn of this century. Meanwhile, the pulp and paper industry developed. It used even smaller white spruce trees and larger fir trees. This industry exhausted this class of trees by the 1950s, and it had to make technological adjustments to utilize even smaller trees and less desirable species.

The authors of most chapters made excellent suggestions as to how mankind might cope with current and pending environmental problems that could limit human development. However, only a few proposed plans for sustainable development. Obviously, many unmet challenges remain in this arena of discussion.

Perhaps the most popular paper with this book's contributors was by the Canadian ecologist C. S. Holling. His excellent discussion of "local surprise" in the management of ecosystems showed how an equilibrium-centered view of nature had resulted in the structural change of many ecosystems. Natural resource managers have reduced the heterogeneity of key ecosystem variables while the not so constant natural system has slowly moved into a different state without that change being recognized by management. The surprise happens when this recognition finally occurs.

An excellent example is the suppression of wildfire in the northern Rocky Mountains of the United States for the past 90 years. This has resulted in the build-up of higher than normal fuel loads. The enormous fires in Yellowstone Park in the summer of 1988 may not have grown so large if wildfire's role in forest ecosystems had been recognized 90 years ago.

This book is for anyone seeking a deeper and broader understanding of the major international environmental issues facing most of mankind. The papers are semi-technical and quite accessible to most people who are not experts in the topics. Even the discussion of atmospheric chemistry was easy to follow!

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The Superior North Shore: A Natural History of Lake Superior's Northern Lands and Waters

By T. F. Waters. 1987. University of Minnesota Press, Minneapolis. xix + 361 pp., illus. U.S. $25.

The Superior North Shore integrates the geomorphology, prehistory, history, and biology of the north shore of Lake Superior into one comprehensive volume. Ignoring political boundaries, the author has taken a refreshing geographical perspective of the region. Containing a wealth of scientific information, the book is written in easy-to-read and understandable language that is equally suited to the layman and the scientist.

This book presents a fascinating chronology of events from the earliest geological formations to the present day, and shatters the image of the Superior shoreline as a pristine and undisturbed environment. With this chronology comes an important sense of historical perspective, from glaciation, to the ebb and flow of various native tribes and populations, to the modern day presence of Woodland Caribou as one of the few surviving representatives of the Ice Age. Impacts of human presence and exploitation on the area's natural resources are vividly described, including the early Indian reliance on the Lake Superior fisheries resource, the fur traders' reliance on waterways and exploitation of furbearer populations, and the relatively recent mining, logging, and commercial fishing.

However, this holistic approach to the region's natural history is lost once the author reaches his area of expertise — fisheries. Fully 70 pages are devoted to detailed discussions of the Sea Lamprey invasion, other introduced fish species, commercial and sport fishing. While interesting, there is far too much detail given the otherwise general intent of the book. The author acknowledges this shortcoming but makes no apology, citing as rationale the importance of fisheries to human history, the ecological seriousness of the Sea Lamprey introduction, and personal bias. It does, however, change the pace and direction of the book. The subsequent natural history chapters are disappointingly cursory and incomplete, approaching tokenism. Birds and mammals receive a scant 14 and 13 pages of text respectively. The discussion on mammals relates almost entirely to the three deer species native to the area. The avian chapter contains a rather simplified discussion of the habitat separation of bird species pairs by coniferous composition (eg. Canada vs Blue jay, Spruce vs Ruffed grouse, Boreal vs Black-capped chickadee). Nongame birds, exclusive of raptors and colonial waterbirds, receive little attention.

There are two major deviations from the Lake Superior North Shore theme, albeit related to it. One is to discuss Isle Royale and the other to cover the Lake Nipigon Basin. Both areas are unique and interesting, and of obvious interest to the author, yet their inclusion detracts from the Superior north shore emphasis.

The book ends with a discussion of state, provincial, and national parks, including their major points of interest. This will be of value to the travelling visitor and the local resident. The simple addition of addresses where more detailed information on these parks and other local attractions could be obtained would have heightened the book's value, although it is not intended to be a travel guide. There is sufficient information to whet the appetite, but not enough to plan a trip.

There are no photographs in *The Superior North Shore*, rather there are a number of sketches by C. Y. Waters depicting the local scenery and events. This enhances the book's appeal, as the sketches capture the subtle mood of the Lake Superior environment far better than photographs could. A large number of maps are also used to portray the area's history and resources. Several maps accurately locate the city of Thunder Bay, while others erroneously show the location of the former cities of Port Arthur and Fort William prior to their amalgamation into Thunder Bay.

This book is a very useful introduction to the human and natural history of the Lake Superior country. All who have been exposed to the region will both learn from and enjoy this book. The major drawback is the loss of a central focus as the book proceeds, followed by a weak summary attempt at integration. *The Superior North Shore* will appeal to historians, naturalists, and resource managers, as well as anyone with an interest in or fondness for the area.

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The Book of Naturalists: An Anthology of the Best Natural History

Edited by William Beebe. 1988. Reprint of 1944 edition. Princeton University Press, Princeton, New Jersey. xiv + 499 pp., illus.

First published in 1944, *The Book of Naturalists* is a wide-ranging collection of natural history writings from ancient times to the early twentieth century. Many of the selections come as little surprise. In part one, the reader is treated to the work of such luminaries as Linnaeus, Humboldt, Audubon, and Thoreau.

Part two, on the other hand, is largely concerned with the Darwinian revolution and its aftermath. This comprises more than three-quarters of the book. What is particularly noteworthy about the selections is the natural scientists who have been excluded — men such as Buffon, Lamarck, Ray, Cuvier, Gray, Coues, and Allen. In keeping with editor William Beebe's background, moreover, most of the excerpts deal with zoological topics, especially birds and mammals; there are only a few entries on plants.

Finally, Beebe's remarks have assumed a historical significance of their own. Writing towards the end of the Second World War, Beebe compares man's steady increase of scientific knowledge with the evolution of biological life. "No corresponding menace or peril, however global, now or in the future" he writes, "can ever put an end to this advance of the mind and the spirit of man" (viii). One wonders whether current environmental challenges will mean that these bold words have a hollow ring in the long run.

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MISCELLANEOUS

Statistical Ecology: A Primer on Methods and Computing

By John A. Ludwig and James F. Reynolds. 1988. Wiley, New York. xviii + 337 pp., illus. + program disk. U.S. $34.95.

This book was written as an introduction to some of the current statistical topics in community ecology. The authors have not attempted to provide an exhaustive survey of statistical methods in ecology, or to rigorously present the statistical theory behind the methods covered. Their objective was a primer with emphasis on practical application of selected methods. The book achieves this objective.

The material is arranged in seven parts. Part I outlines the general form of the data matrix that community ecologists work with — multiple biotic (species) and abiotic (environmental) variables measured on sampling units in space or time — and the general objective of detecting spatial or temporal patterns. The importance of sampling design is emphasized briefly, although there is surprisingly little discussion of this important topic.

The remaining six parts of the book (23 chapters) deal with spatial pattern analysis (single species), species abundance relations and diversity indices, species affinity and niche overlap, community classification (e.g., association and cluster analysis), community ordination (e.g., principal components and correspondence analysis), and community interpretation (e.g., discriminant analysis). Different chapters within each part describe specific methods. Each chapter begins with a statement of the general approach, followed by a step-by-step description of the procedure. Then several examples of the computations are given from start to finish. Additional related topics are briefly discussed for the reader who wishes to pursue them further, and a summary of main points and recommendations is presented.

These last two sections of each chapter are particularly valuable. Here, variations on each method are discussed, advantages and disadvantages are listed, and potential pitfalls of misapplication or misinterpretation are highlighted. The recommendations point to superior methods where consensus exists, and often advise exploratory application of several methods in order to identify meaningful ecological patterns.

The emphasis of the book, in the examples used, is clearly on detection of spatial patterns, although it is mentioned that sampling units may be distributed either in time or space, and that spatial analysis may be performed at different points in time. Some discussion of the commonly encountered problem of confounding spatial and temporal patterns would have been useful.

There is necessarily some simplification in a primer-level text of this nature. For example, in Chapter 3, the fit of the negative binomial distribution is first presented as a test for 'clumped' dispersion of individual organisms. The reader is later surprised to find that some data may fit both the negative binomial and the Poisson statistical distribution for random dispersion., In fact, the negative binomial is a very flexible distribution which may fit either clumped or essentially random dispersion patterns, depending on the value of its k parameter. However, in general, the book achieves a good balance between oversimplification and statistical rigor.

The BASIC computer programs provided on floppy disk permit the reader to experiment with the various methods described, using his or her own data, and to acquire a feeling for method performance on different kinds of data. In addition, the reader is directed to commercial statistical software for some of the techniques.

The book is well indexed, and offers a good selection of recent original literature for readers who wish to pursue particular topics in detail. The occasional typographical errors do not seriously affect its readability. Both students and practicing community ecologists will find the book a valuable addition to their libraries.

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NEW TITLES

Zoology

***The ancestral kestrel.** 1987. Edited by David M. Bird and Reed Bowman. Raptor Research Reports No. 6. Raptor Research Foundation, Carpenter St. Croix Nature Center, Hastings, Minnesota. vii + 178 pp., illus. U.S.$12.50 plus shipping.

The archaeology of animals. 1987. By Simon J. M. Davis. Yale University Press, New Haven. 224 pp., illus. U.S.$27.50.

Atlas on the biology of soil arthropods. 1987. By Gerhard Eisenbeis and Wilfred Wichard. Springer-Verlag, New York. xiv + 437 pp., illus. U.S.$120.

Behavioral adaptations to intertidal life. 1988. Edited by Guido Chelazzi and Marco Vannini. Proceedings of a symposium, Casiglioncello, Italy. 21-26 May, 1987. Plenum, New York. c510 pp. U.S.$95.

The behavioural ecology of ants. 1987. By John H. Sudd and Nigel R. Franks. Chapman and Hall, New York. x + 206 pp., illus. Cloth U.S.$55; paper U.S.$23.

Biogeography and taxonomy of honeybees. 1987. By Friedrich Ruttner. Springer-Verlag, New York. xii + 284 pp., illus. U.S.$87.50.

The biology and evolution of lungfishes. 1987. Edited by William E. Bemis, Warren W. Burggren, and Norman E. Kemp. From a symposium, Denver, December, 1984. Liss, New York. viii + 383 pp., illus. U.S.$49.50.

Biology and management of the Cervidae. 1987. Edited by Christen M. Wemmer. From a symposium, Front Royal, Virginia, August, 1982. Smithsonian Institute Press, Washington. xiv + 577 pp., illus. Cloth U.S.$40; paper U.S.$29.95.

***Biology of the land crabs.** 1988. Edited by Warren W. Burggren and Brian R. McMahon. Cambridge University Press, New York. xii + 479 pp., illus. U.S.$59.50.

***Birdfinding guide to the Toronto region.** 1988. By Clive E. Goodwin. Revised edition. Goodwin, Weston, Ontario. v + 153 pp., illus. $8.95 + $3.05 postage.

The birdwatcher's handbook: field ornithology for backyard naturalists. 1987. By Laura O'Biso Socha. Dodd, Mead, New York. x + 182 pp., illus. Cloth U.S.$16.95; paper U.S.$7.95.

Bryozoa: present and past. 1987. Edited by June R. P. Ross. From a conference Belligham, Washington, August, 1986. Western Washington University, Bellingham. viii + 333 pp., illus. U.S.$40.

***Butterflies of the world.** 1988. By Rod and Ken Preston-Mafham. Facts on File, New York. 192 pp., illus. U.S.$22.95; $30.95 in Canada.

Conodonts: investigative techniques and applications. 1987. Edited by Ronald L. Austin. From a symposium, Nottingham, United Kingdom, 1985. Horwood

(Distributed by Wiley, New York). 422 pp., illus. U.S.$89.95.

***The coyote: defiant songdog of the west.** 1988. By Francois Leydet. Revised edition. University of Oklahoma Press, Norman. 224 pp., illus. Cloth U.S.$19.95; paper U.S.$8.95.

Evolution of longevity in animals: a comparative approach. 1987. Edited by Avril D. Woodhead and Keith H. Thompson. From a symposium, Upton, New York, October, 1986. Plenum, New York. x + 354 pp., illus. U.S.$59.50.

Form and function in birds, volume 4. 1988. Edited by A. S. King and John McLelland. Academic Press, San Diego. c576 pp. cU.S.$158.

A functional biology of echinoderms. 1987. By John Lawrence. Johns Hopkins University Press, Baltimore. xii + 340 pp., illus. U.S.$56.50.

***Handbook of animal diversity.** 1986. By Richard E. Blackwelder and George S. Caronian. CRC Press, Boca Raton, Florida. 555 pp., illus. U.S.$195 in U.S.A.; U.S.$225 elsewhere.

***Hawks in flight: the flight indentification of North American migrant raptors.** 1988. By Pete Dunne, David Sibley, and Clay Sutton. Hougton Mifflin (Distributed by Thomas Allen, Markham, Ontario). viii + 254 pp., illus. $26.95.

Kangaroos: their ecology and management in the sheep rangelands of Australia. 1987. Edited by Graeme Caughley, Neil Shepherd, and Jeff Short. Cambridge University Press, New York. xiv + 253 pp., illus. U.S.$49.50.

Living snakes of the world in color. 1987. By John M. Mehrtens. Sterling, New York. 480 pp., illus. U.S.$45.

The natural history of larval mosquito habitats. 1988. By Marshall Laird. Academic Press, San Diego. 426 pp. cU.S.$95.

The natural history reader in animal behavior. 1987. Edited by Howard Topoff. Columbia University Press, New York. 245 pp., illus. Cloth U.S.$30; paper U.S.$17.

New generation guide to the birds and Europe. 1987. By Christopher Perrins. University of Texas Press, Austin. 320 pp., illus. U.S.$14.95.

Nova Scotia's snowshoe hare: life history and management. 1988. By Donald Dodds. Nova Scotia Department of Lands and Forests, Halifax. $5.

The peaceable kingdom: a year in the life of America's oldest zoo. 1988. By John Sedgwick. Morrow, New York. 413 pp., illus. U.S.$19.95.

***Peregrine falcon populations: their management and recovery.** 1988. Edited by Tom J. Cade, James H. Enderson, Carl G. Thelander, and Clayton M. White. Proceedings of a conference, Sacramento, 1985. Peregrine Fund, Boise, Idaho. xviii + 948 pp., illus. + plates. U.S.$39 + U.S.$3.75 postage.

Right whales: past and present status. 1986. Edited by Robert L. Brownell, jr., Peter B. Best, and John H. Prescott. From a workshop, Boston, June, 1983. International Whaling Commission, Cambridge, United Kingdom. viii + 289 pp., illus. U.S.$60.

Saving America's wildlife. 1988. By Thomas R. Dunlap. Princeton University Press, Princeton. 264 pp. U.S.$29.

Sharks of the order Carcharhiniformes. 1988. By L. J. V. Compagno. Princeton University Press, Princeton. 600 pp., illus. U.S.$114.50.

***The sparrows.** 1988. By J. Denis Summers-Smith. Poyser (Distributed by Buteo, Vermillion, South Dakota). 342 pp., illus. + plates. U.S.$57.50.

Tiger moon. 1988. By Fiona and Mel Sunquist. University of Chicago Press, Chicago. 208 pp., illus. U.S.$24.95.

Tigers of the world: the biology, biopolitics, management, and conservation of an endangered species. 1987. Edited by Ronald L. Tilso and Ulysses S. Seal. From a symposium, Minneapolis, April, 1986. Noyes, Park Ridge, New Jersey. xxx + 510 pp., illus. U.S.$64.

***Waterfowl in winter.** 1987. Edited by Milton W. Weller. University of Minnesota Press, (Canadian distributor Beaverbooks, Markham, Ontario). 640 pp., illus. Cloth $71.95; paper $29.50.

Whales, dolphins, and porpoises of the world. 1987. By Mary L. Baker. Doubleday, New York. 224 pp., illus. U.S.$35.

Botany

Arctic and alpine mycology, II. 1987. Edited by Gary A. Laursen, Joseph F. Ammirati, and Scott A. Redhead. From a symposium, Fetan, Switzerland, 1984. Plenum, New York. x + 364 pp., illus. U.S.$65.

***The atlas of the vascular plants of Utah.** 1988. By Beverly J. Albee, Leila M. Schultz, and Sherel Goodrich. Utah Museum of Natural History, Salt Lake City. 685 pp., illus. U.S.$26 plus U.S.$4 shipping.

The biology and utilization of shrubs. 1988. Edited by Cyrus M. McKell. Academic Press, San Diego. c632 pp. U.S.$125.

The biology of dinoflagellates. 1987. Edited by F. J. R. Taylor. Blackwell Scientific, Palo Alto, California. xii + 785 pp., illus. U.S.$180.

The carnivorous plants. 1988. By Barrie E. Juniper, R. J. Robins, and D. M. Joel. Academic Press, San Diego. c416 pp. cU.S.$150.

The cattleyas and their relatives, volume 1: the cattleyas. 1988. By Carl L. Withner. Timber Press, Portland, Oregon. 150 pp., illus. U.S.$29.95.

Climate and plant distribution. 1987. By F. I. Woodward. Cambridge University Press, New York. xii + 174 pp., illus. Cloth U.S.$39.50; paper U.S.$14.95.

***Environmental biology of agaves and cactus.** 1988. By Park S. Nobel. Cambridge University Press, New York. 270 pp. U.S.$59.50.

†**The evolution and classification of flowering plants.** 1988. By Arthur Cronquist. Second edition. New York Botanical Garden, Bronx. x + 556 pp., illus. U.S.$45.35 in U.S.A.; U.S.$46.80 elsewhere.

†**Flowers from the royal gardens of Kew: two centures of Curtis's Botanical Magazine.** 1988. By Ruth L. A. Stiff. University Press of New England, Hanover, New Hampshire. 80 pp., illus. U.S.$15.95.

†**Fruits and berries of the Pacific northwest.** 1988. By David C. Flaherty and Sue Ellen Harvey. Alaska Northwest, Edmonds, Washington. 101 pp., illus. U.S.$24.95; $31.70 in Canada.

†**Gasteromycetes: morphological and developmental features with keys to the orders, families, and genera.** 1988. By Orson K. Miller, jr. and Hope H. Miller. Mad River Press, Eureka, California. ix + 157 pp., illus. U.S.$24.95.

†**How to identify mushrooms to genus IV: modern genera.** 1988. By David L. Largent and Timothy J. Baroni. Mad River Press, Eureka, California. vi + 277 pp. U.S.$22.95.

Mushrooms: a quick reference guide to mushrooms of North America. 1987. By Alan Bessette and Walter J. Sundberg. Macmillan, New York. 173 pp., illus. U.S.$24.95.

Native shrubs and woody vines of the southeast: landscape uses and identification. 1989. By Leonard E. Foote and Samuel B. Jones, jr. Timber Press, Portland, Oregon. c260 pp., illus. U.S.$32.95.

New generation guide to the wild flowers of Britain and northern Europe. 1987. By Alistair Fitter. University of Texas Press, Austin. 320 pp., illus. U.S.$14.95.

Photographing wildflowers: techniques for the advanced amateur and professional. 1988. By Craig and Nadine Blacklock. Western Producer Prairie Books, Saskatoon. 64 pp., illus. $14.95.

Rhododendron species, volume 2, part 1: Elepidotes. 1989. By H. H. Davidian. Timber Press, Portland, Oregon. c350 pp., illus. + plates. U.S.$54.95.

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†**Weeds of the United States and their control.** 1987. By Harri J. Lorenzi and Larry S. Jeffery. Van Nostrand Reinhold (Distributed by Gage, Agincourt, Ontario). 355 pp., illus. + plates. $101.20.

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Acid rain: the relationships between sources and receptors. 1987. Edited by James C. White. From a conference, Washington, December, 1986. Elsevier, New York. xvi + 223 pp., illus. U.S.$59.

Advances in the study of behavior, volume 18. 1988. Edited by Jay S. Rosenblatt, Colin Beer, Marie-Claire Bunsel, and Peter J. B. Slater. Academic Press, (Harcourt, Brace, Jovanovich, Orlando, Florida). 208 pp. U.S.$45.

***The appropriation of nature: essays on human ecology and social relations.** 1987. By Tim Ingold. University of Iowa, Iowa City. ix + 287 pp., illus. U.S.$35.

†**The atlas of natural wonders: earth's most spectacular sights.** 1988. By Rupert O. Matthews. Facts on File, New York. 240 pp., illus. U.S.$35; $45 in Canada.

Backtrackings: the way of a naturalist. 1987. By Ted Levin. Chelsea Green, Chelsea, Vermont. x + 220 pp., illus. U.S.$17.95.

Beginnings: the story of origins — of mankind, life, the earth, the universe. 1987. By Isaac Asimov. Walker, New York. 320 pp. U.S.$19.95.

Biology and the mechanics of the wave-swept environment. 1988. By Mark W. Denny. Princeton University Press, Princeton. 400 pp., illus. Cloth U.S.$69; paper U.S.$28.75.

Biosphere: the realm of life. 1987. By Robert A. Wallace, Jack L. King, and Gerald P. Sanders. Scott, Foresman, Glenview, Illinois. xxviii + 780 pp., illus. + appendices. U.S.$33.

The chemistry of acid rain: sources and atmospheric processes. 1987. Edited by Russell W. Johnson, et al. Based on a symposium, New York, April, 1986. American Chemical Society, Washington. xii + 337 pp., illus. U.S.$59.95.

Coevolution of fungi with plants and animals. 1988. Edited by K. A. Piroznski and D. L. Hawksworth. Academic Press, (Harcourt Brace Jovanovich, Orlando, Florida). c300 pp. cU.S.$68.

†**The conservation of Australian wetlands.** 1988. Edited by A. J. McComb and P. S. Lake. Surrey Beatty, Chipping Norton, Australia. xii + 196 pp., illus. U.S.$58.

Crossing open ground. 1988. By Barry Lopez. Scribner's, New York. 208 pp. U.S.$17.95.

The design of life. 1987. By Renato Dulbecco. Yale University Press, New Haven. 453 pp., illus. U.S.$39.95.

Developments in numerical ecology. 1987. Edited by Pierre Legendre and Louis Legendre. From a workshop, Roscoff, France, June, 1986. Springer-Verlag, New York. xii + 585 pp., illus. U.S.$149.70.

Disappearing rainforest. 1988. By Robert Prosser. Dyrad, Pomfret, Vermont. 48 pp., illus. U.S.$16.95.

Dynamic modeling in behavioral ecology. 1988. By Marc Mangel and Colin W. Clark. Princeton University Press, Princeton. c380 pp. Cloth U.S.$57.50; paper U.S.$18.50.

Ecological diversity and its measurement. 1988. By Anne E. Magurran. Princeton University Press, Princeton. 215 pp., illus. Cloth U.S.$45; paper U.S.$14.95.

Encyclopedia of Indian natural history: centenary publications of the Bombay Natural History Society, 1883-1983. 1987. Edited by R. E. Hawkins. Oxford University Press, New York. xvi + 620 pp., illus. + plates. U.S.$49.95.

The evolution of complexity by means of natural selection. 1988. By John Tyler Bonner. Princeton University Press, Princeton. c344 pp., illus. Cloth U.S. $46; paper U.S.$16.25.

The evolution of individuality. 1988. By Leo W. Bass. Princeton University Press, Princeton. 240 pp., illus. Cloth U.S.$46; paper U.S.$15.

Extinction. 1987. By Steven M. Stanley. Scientific American Books (distributed by Freeman, New York). xii + 242 pp., illus. U.S.$32.95.

Forecasts and environmental decision making: the content and predictive accuracy of environment impact statements. 1987. By Paul J. Culhane, H. Paul Friesma, and Janice A. Beecher. Westview, Boulder, Colorado. x + 306 pp., illus. U.S.$28.

The fourth world: the heritage of the Arctic and its destruction. 1987. By Sam Hall. Knopf, New York. 240 pp. U.S.$17.95.

From clocks to chaos: the rhythms of life. 1988. By Leon Glass and Michael C. Mackey. Princeton University Press, Princeton. 256 pp., illus. Cloth U.S.$52; paper U.S.$16.25.

High altitude tropical biogeography. 1987. Edited by Francois Vuilleumier and Maximina Monasterio. Oxford University Press, New York. xii + 649 pp., illus. U.S.$75.

Life's devices: the physical world of animals and plants. 1988. By Steven Vogel. Princeton University Press, Princeton. c350 pp., illus. Cloth U.S.$52; paper U.S.$20.75.

Living treasures: an odyssey through China'a extraordinary nature reserves. 1987. By Tang Xiyang. Bantam, New York. 208 pp., illus. U.S.$29.95.

Making soil and water conservation work: scientific and policy perspectives. 1987. Edited by Daniel W. Halbach, C. Ford Runge, and William E. Larson. Soil Conservation Society of America, Ankeny, Iowa. xii + 174 pp., illus. U.S.$10.

Mathematical evolutionary theory. 1988. Edited by Marcus W. Feldman. Princeton University Press, Princeton. c400 pp., illus. Cloth U.S.$69; paper U.S.$23.

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Cover: A juvenile Blackpoll Warbler, *Dendroica striata*, photographed in Duck Mountain Provincial Park, Manitoba, 8 July 1987 (see note by W. J. Walley pages 396–397). Photograph courtesy of William J. Walley.

The Canadian Field-Naturalist

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HARVARD UNIVERSITY

Wolf, *Canis lupus*, Population Characteristics and Prey Relationships Near Simonette River, Alberta

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Bjorge, Ronald R., and John R. Gunson. 1989. Wolf, *Canis lupus*, population characteristics and prey relationships near Simonette River, Alberta. Canadian Field-Naturalist 103(3): 327–334.

Wolf (*Canis lupus*) populations and prey relationships were studied during 1975-81 in northwestern Alberta as part of an evaluation of Wolf predation of livestock. Density of Wolves increased from one Wolf/92 km² during the initial winter to one Wolf/42 km² during the population high in 1979. Overall, 12% were lone Wolves. Mean territory size of four packs over seven summers was 233 km² (100-276 km²) compared to 424 km² (198-850 km²) for four packs over nine winters. Average territory size of three packs over six years was 572 km² (296-878 km²) compared to 2191 km² (607-4900 km²) for ranges of lone Wolves. Of 26 live-captured Wolves, 54% were females and 23% were pups. Mean over summer increase from late winter populations was 60% while overwinter loss averaged 30%. Minimum consumption rate for one pack during 51 days in winter was 0.12 kg/kg Wolf/day. Of 61 kills examined, 39 were Moose (*Alces alces*), 17 Elk (*Cervus elaphus*) and 5 deer (*Odocoileus* spp.). Old Moose (≥ 9.5 y) were represented in Wolf kills more often than in hunter kills while the opposite was true for younger Moose. Among Elk, Wolves killed primarily calves and young cows. Wolves selected Elk over Moose. Wolf predation was not limiting the Moose or deer populations; however, natural and human predation (hunting) approximated Elk recruitment.

Key Words: Wolf, *Canis lupus*, populations, prey, Moose, *Alces alces*, Elk, *Cervus elaphus*, Simonette River, Alberta.

Effect of Wolf (*Canis lupus*) predation on populations of hoofed mammals has varied from little or no effect (Fuller 1962) to virtual extirpation (Mech and Karns 1977). In most cases, where predation by Wolves was considered important to declining prey populations, other factors were involved. Winter severity, prey habitat deterioration, human harvest and other predators contributed to these declines (Peterson 1977; Davis et al. 1980; Gasaway et al. 1983; Ballard et al. 1987).

In Alberta, the impact of Wolves on ungulates has been investigated in several areas. Fuller and Keith (1980) reported Wolves of one pack were the major limitation on a stable or slowly declining Moose (*Alces alces*) population (Hauge and Keith 1981) in the northeast. Schmidt and Gunson (1985, Alberta Fish and Wildlife Division, unpublished report) concluded predation by a pack of 9-14 Wolves in mountainous, western Alberta was the major source of mortality of a declining, unproductive herd of Elk. Oosenbrug and Carbyn (1985) noted a combination of low calf production and Wolf predation prevented an increase in the Bison (*Bison bison*) population of Wood Buffalo National Park, Alberta. We observed dynamics of Wolves and ungulates supplementary to Wolf-cattle investigations in northwestern Alberta during 1975-81 (Bjorge 1983; Bjorge and Gunson 1983, 1985). In this paper, we estimate the effect of Wolf predation on Moose, Elk (*Cervus elaphus*) and deer (*Odocoileus* spp.) and record details of Wolf population characteristics.

Study Area

The area (about 2000 km²), located in northwestern Alberta at approximately 54°50′ latitude and 117°30′ longitude, is generally flat, but interrupted by numerous creeks and the Simonette and Latornell rivers. The valleys of the rivers are broad and up to 120 m deep. Elevation varies from 670 to 760 m and the soils are grey-wooded (Odynsky 1968). The climate is usually characterized by warm summers and cold winters, with mean temperatures of 16.0°C in July and -13.5°C in December, and with 60-85 frost-free days.

Winters were mild during the study period. Mean annual snowfall November-April, 1976-81 was 98 cm compared to the 40-year mean of 159 cm. Mean monthly temperature during winter was -5.6°C during the study period compared to a 40-year mean of -9.9°C. Snow accumulation during winters, 1979-80 and 1980-81 was insufficient for Moose surveys.

The area is within the boreal forest (Rowe 1972) and contains two ecoregions, the Boreal Foothills and the Boreal Mixedwood (Strong and Leggat 1981). The area has been ecologically classified and has moderate to high capability for improved grazing and Moose habitat (Nelson 1983). Vegetative growth, with aspen (*Populus tremuloides*) as the dominant and a variety of understory communities, is productive with a high growth rate. Soils are often imperfectly drained with seasonal flooded depressions. Balsam Poplar (*Populus balsamifera*), willow (*Salix* spp.) and alder (*Alnus* spp.) are common. Only occasional natural meadows, two artificial clearings (> 250 ha) and numerous trails and petroleum seismic lines were void of trees.

Common wildlife (in addition to Wolves) included Moose, Black Bear (*Ursus americanus*), Coyote (*Canis latrans*), Snowshoe Hare (*Lepus americanus*), and Beaver (*Castor canadensis*). Elk, White-tailed Deer (*Odocoileus virginianus*), and Mule Deer (*Odocoileus hemionus*) were locally abundant. Seven grazing leases were located within the study area which pastured between 1500 and 2300 cattle during the May-October grazing period.

Methods

Twenty-five Wolves were trapped with 48 and 114 Newhouse traps; one Wolf was taken in a neck snare similar to those used by Nellis (1968) for Coyotes. Traps were set primarily during April-November and placed along trails, at kill sites and Wolf scent stations. Captured Wolves were restrained with a modified hay fork or forked sticks, measured, examined, radio-collared and released. One Wolf died in the trap; 25 were radio-collared, including 6 pups of 5-8 months of age. Collars on two of the smallest pups were fitted with foam to allow for growth. Four lone Wolves were collared as well as 21 Wolves in 5 packs (range 1-6 per pack). Relocations of Wolves were made from fixed-wing aircraft, usually twice weekly during May-October (summer) and weekly during November-April (winter). Ranges were determined according to the polygon-perimeter method of Mohr (1947).

Histories of packs and individual Wolves were reconstructed from analyses of radio-collared animals, carcasses, tracks, and colours of animals seen. During winter, project personnel travelled by snowmobile; horses and all-terrain vehicles were utilized during the snow free months.

For live-captured Wolves, pups were distinguished from adults by size. Twenty-six Wolves, taken in an experimental governmental control program during 1979-1981 (Bjorge and Gunson 1985), were autopsied and data on size, weight, sex, age, reproductive status and disease or abnormalities were recorded. Age was determined by comparing tooth replacement and wear, skull development and cementum annuli in the first lower pre-molar. Based on comparisons utilizing 563 skulls collected in Alberta during 1972-79, but without known-aged skulls, JRG believes the method provides useful results. Using these techniques, Wolves in their first year of life can be separated from older Wolves with little difficulty.

Ungulate prey were located primarily during aerial radio-monitoring of Wolves; a few were discovered during ground investigations. Kills, as opposed to scavenging, were determined from evidence of chase, including tracks in the snow and/or a blood trail. The incisor bar and a leg bone, usually the femur, were collected at the kill site, if available. Bone marrow fat (BMF) levels of Wolf-killed ungulates were determined by ether extraction at the Toxicology Laboratory, Alberta Department of Agriculture, Edmonton.

Recreational hunters were interviewed in the field during the fall hunting season. Mandibles for aging and specifics of their ungulate harvest were collected. Age of Wolf-killed and hunter-killed ungulates were determined by histological cross-section of incisors.

Two types of aerial surveys were utilized to estimate distribution, numbers and structure of ungulate populations. First, 43 randomly-chosen 1-mi^2 quadrats were surveyed by helicopter during December or January to establish population trends and estimate density of Moose. Second, Elk and Moose were classified by sex (with or without antlers) and age during December (prior to 10 December) fixed-wing surveys (east-west transects spaced at 2-3 mi). All surveys were flown 100-150 m above ground. Additional information on Elk, Moose and deer was collected from occasional observations during aerial relocations of Wolves and ground surveys.

Criteria utilized to assess impact of Wolf predation on ungulate prey included availability of ungulate biomass/Wolf (Bergerud et al. 1983; Gasaway et al. 1983), changes in prey populations with increasing Wolf densities (Peterson 1977), and response of prey populations to Wolf control (Ballard et al. 1981; Gasaway et al. 1983). Calculations of Moose biomass were based on weights of Moose from unpublished Alberta records (G. Lynch, Alberta Fish and Wildlife Division, personal communication).

Results and Discussion

Numbers and Densities of Wolves

During the study period, but prior to experimental Wolf reduction, Wolves increased from about 14-15 during winter, 1975-76 to a high of 40 during fall 1979 (Table 1). Prior to the first winter, Wolf populations were recovering from governmental Wolf control conducted during the early 1970s (Alberta Fish and Wildlife Division, unpublished records). Twenty-six Wolves were removed during an evaluation of cattle predation during 1979-1981 causing a decline in numbers to 13 in 1980 and 3 in 1981 (Bjorge and Gunson 1983, 1985). The mean finite rate of increase (Keith 1983) over 4 years was 1.3 — a decline from 1.7 to 1.0 during 1975-80.

The number of packs of more than two Wolves increased from three during winter 1975-76 to six during winter 1978-79. Mean pack size during midwinter was six (range 2-12). Most Wolves in the area belonged to packs; a mean of 12% of the population were lone Wolves. Occurrence of lone Wolves in other populations ranged from 10% (Stephenson 1978; Carbyn 1980) to 32% (Mech 1973). Our results are similar to those of Fuller and Keith (1980) from northeastern Alberta, who observed 13% lone Wolves.

Intra-pack densities averaged 61 km²/Wolf (range 33-97 km²/Wolf) for nine pack/winters (one pack over two winters = 2 pack/winters) and 39 km²/Wolf (range 10-77 km²/Wolf) for six pack/summers. During winter 1979-80, mean density for four packs was 52 km²/Wolf. Overall density the winter prior to Wolf reduction was 42 km²/Wolf (total range was 1670 km) considering the occurrence of lone Wolves, pairs and the spaces between pack territories. These observed densities were comparable to the 40-65 km²/Wolf observed on Bison ranges in Wood Buffalo National Park, Alberta (Oosenbrug and Carbyn 1985), but were greater than those observed elsewhere in the province (Table 2). See Ballard et al. (1987) for a recent summary of Wolf densities ranging from 1 Wolf/8-500 km².

Range and Territory

Territories of packs were greater during winter than summer as observed elsewhere (Carbyn 1975; Stephenson 1978; Fuller and Keith 1980). Four packs over a total of seven pack/summers averaged 233 km² (100-476 km²), whereas, four packs over a total of nine pack/winters averaged 424 km² (198-850 km²).

Average annual range of four lone Wolves was 2191 km² (range 607-4900 km²) compared to 572 km² for three packs over six pack/years (range 296-878 km²). Mech (1977) and Fritts and Mech (1981) in Minnesota, Stephenson (1978) in Alaska, and Carbyn (1980) in Manitoba similarly observed large ranges of lone Wolves. In contrast, in northeastern Alberta, ranges of 195-1997 km² were recorded for packs while two lone Wolves covered ranges of 98 and 237 km² (Fuller and Keith 1980).

Sex and Age Ratios

Of 26 live-captured Wolves, 14 (54%) were females, and from 39 Wolf carcasses examined, 20 (51%) were females. Of the 26 live Wolves, 6 (23%) were less than 1-year old, this being somewhat lower than recorded elsewhere (range 15-64%, Mech 1977; Stephenson 1978; Carbyn 1980; Fritts and Mech 1981), perhaps because we did not commonly trap at den or rendezvous sites. Of 34 aged carcasses in our area, 12 (35%) were pups. This compares to 48% pups in Algonquin Provincial Park, Ontario (Pimlott et al. 1969), 47% pups in south-central Alaska (Ballard et al. 1981), and 30% pups in interior Alaska (Gasaway et al. 1983).

Reproduction

All four packs over 13 pack/summers appeared to produce pups each year. Each of two necropsied females had eight placental scars; three more were pregnant with 4, 5, and 6 fetuses. A female found dead in one of our traps on 31 May 1978 had four active nipples. Two live-captured females which were suckling pups had six and five active nipples.

TABLE 1. Estimated number of Wolves during early winter near the Simonette River, northwestern Alberta.

Early Winter	Number of Pack Wolves	Number of Lone Wolves	Total Population	Finite Rate of Increase[a]
1975-76	12	2-3	14-15	—
1976-77	22	2-3	24-25	1.7
1977-78	29-31	3-4	32-35	1.4
1978-79	33-35	3-4	36-39	1.1
1979-80	37	3	40	1.0
1980-81[b]	10	3	13	

[a] Average rate of increase was 1.3.

[b] Government Wolf control was conducted during late winter, 1979-80.

TABLE 2. Densities of Wolves during winter in Alberta.

Area	Years	Number of Wolves	Density (km^2/wolf)	Source
Jasper National Park	1942-46	38-48	225-286	Cowan 1947
	1969-70	48	225	Carbyn 1975
	1974-76	80-100	109-136	Dekker 1986
AOSERP[a]	1976-77	166	151	Fuller and Keith 1980
Swan Hills	1976-77	24	83	Fuller and Keith 1980
Simonette River	1975-76	15	92	Bjorge and Gunson 1983
	1979-80	40	42	
Nordegg	1983-84	13	207	Schmidt and Gunson 1985
	1984-85	23	187	
Wood Buffalo National Park (Bison range)	1977-78	136	40-65	Oosenbrug and Carbyn 1985

[a] Alberta Oil Sands Environmental Research Program area near Fort McMurray

Over-summer increase from late winter populations averaged 60%, similar to that of Fuller and Keith (1980) who observed 61% in northeastern Alberta.

Mortality

Twenty of 25 radio-collared Wolves were known to die during the study period. Of the five Wolves whose deaths were not recorded, one disappeared with a functional collar and the other four were tracked until their transmitters failed, but their ultimate fates were unknown. Three mortalities were capture-related. Two adult Wolves became chilled and wet during capture and died within two weeks and a 5-month pup was unable to relocate her pack after capture and starved. Four Wolves were taken in the Simonette control program and four were taken in other Wolf control programs. Of the nine remaining Wolves, six were shot by hunters or cattlemen, one was run over by a logging truck, one died after removal of most of her pack by Wolf control, and one was snared by a trapper. The four Wolves taken off the study area in other control programs dispersed 40-248 km.

Over-winter losses (including dispersals) in four packs over eight pack/winters, excluding years when governmental Wolf control was conducted, averaged 30%. Other reports of over-winter losses include 24% in northeastern Alberta (Fuller and Keith 1980), 6-46% and 11-21% in Minnesota (Mech 1977a; Fritts and Mech 1981) and 14-67% in Manitoba (Carbyn 1980).

Predation and Consumption Rates

Predation rate and minimum consumption were calculated for the Muskeg Lake Pack of seven Wolves during 2 January to 21 February 1980. The pack was located 16 times during 51 days (1 location/3.1 days). During this period at least seven Moose were killed and consumed including two bulls, two cows, two calves and one of unknown sex and age for a minimum of one kill/7.3 days. Assuming the mean weight of Wolves in this pack was 46 kg [equals the mean weight of five (2 adults, 3 pups) poisoned Wolves on 21 February 1980] a minimum of 5.5 kg/Wolf/day or 0.12 kg/kg Wolf/day was consumed.

This compares with winter consumption rates of 0.12-015 kg/kg Wolf/day for Wolves in northeastern Alberta (Fuller and Keith 1980). Rates in other studies ranged from 0.09-0.37 (Mech 1966; Mech and Frenzel 1971; Kolenosky 1972; Peterson 1977; Peterson et al. 1984; Messier and Crete 1985). Kolenosky (1972) and Mech (1977b) suggested a minimum consumption rate of 0.06 kg/kg Wolf/day is required to maintain body weight in winter and 0.13 kg/kg Wolf/day for all individuals to survive and rear pups successfully. Although Wolves in Alberta are somewhat larger than those in southern Ontario and Minnesota (Gunson and Nowak 1979; Fuller and Keith 1980; Nowak 1983), the Muskeg Lake Pack's consumption rate of 0.12 kg/kg Wolf/day, if sustained over the winter, would have ensured overwinter survival, and probably successful reproduction as well. Observed consumption must be regarded as a minimum as other ungulates and smaller prey have been killed and consumed, but missed in our survey.

Prey Selection

We observed 61 kills of wild Cervidae during five winters, 1976-81. These included 39 Moose, 17 Elk, 2 Mule Deer and 3 White-tailed Deer. Age distribution of Wolf-killed Moose was different from that of hunter-killed Moose from the same area. Old Moose, 9.5 years or older, were represented in Wolf kills more often (57%, N = 21) than in hunter kills (7%, N = 156) ($Chi^2 = 24.01$; df = 1; $P < 0.001$) while the opposite was true for younger Moose (Figure 1). Calves were killed in

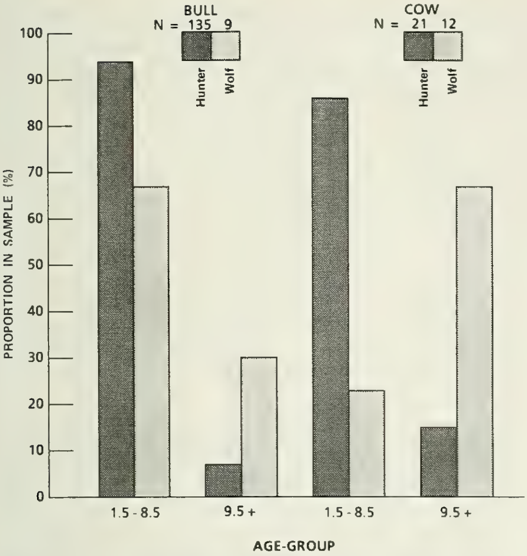

FIGURE 1. Comparison of age distribution of Wolf-killed and hunter-killed Moose over 1 year of age near the Simonette River, Alberta.

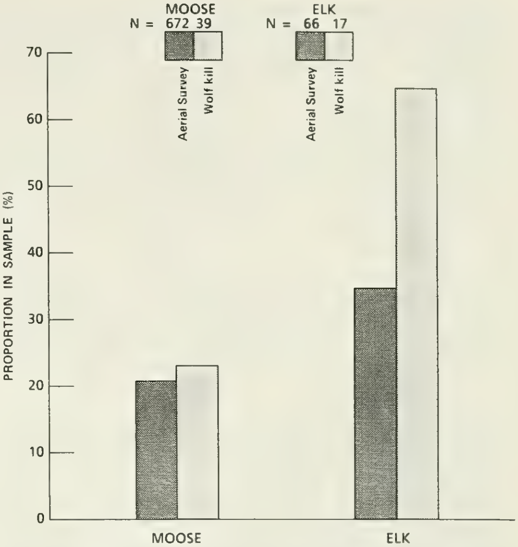

FIGURE 2. Comparison of occurrence of Moose and Elk calves in aerial survey observations and Wolf kills near Simonette River, Alberta.

proportion to their occurrence in the population; 9 of 39 (23%) aged Moose killed by Wolves were calves compared to 22% in the population (Figure 2). However, Wolves killed bull Moose proportionately more often (30%, N = 33) than were observed during aerial transect surveys in fall (12%, N = 611) ($Chi^2 = 6.53$, df = 1, $P < 0.01$). Conversely, cow Moose were represented in Wolf kills proportionately less often (42%, N = 33) than observed during aerial surveys (67%, N = 611), although the difference was not significant ($Chi^2 = 1.95$, df = 1, $P < 0.16$). Early antler drop prior to December may have resulted in some males being counted as females during aerial surveys although no bulls taken by hunters in November were without antlers. In northeastern Alberta, Fuller and Keith (1980) also discovered that Wolves killed yearling and adult bull Moose at a greater rate than bulls were observed in the population.

Eleven of 17 (65%) Elk killed by Wolves were calves while only 35% (N = 66) of the Elk observed during aerial surveys were calves (Table 3, $Chi^2 = 1.87$, df = 1, $P < 0.17$). Of five adult Elk killed, all were cows between two and six years of age. Carbyn (1983) also observed Wolves preying more commonly on cow and calf Elk than on bulls.

Proportionately more Elk than Moose were killed ($Chi^2 = 12.78$, df = 1, $P < 0.001$). Of 51 ungulate kills observed while we aerially located Wolves, 14 were Elk (1 Elk: 3 Moose), whereas, the Elk: Moose ratio observed during aerial surveys on 340 km of transects was 1:10 (Table 3). Although Elk may have been more difficult to observe during aerial surveys than Moose due to smaller size and lighter color, there were clearly far fewer Elk than Moose in our area.

Five deer kills were examined including two fawns (one Mule Deer and one White-tailed Deer), one 8.5 year buck Mule Deer, one 11.5 year buck whitetail, and one unaged adult doe whitetail. We believe Wolves killed proportionally more deer than the observed 8% of kills. Deer, being smaller, were likely more difficult to locate than other Wolf-killed ungulates. Of 15 hunter-killed deer harvested in the area and submitted to the Alberta Fish and Wildlife Division, none was older than 7.5 years. Although the sample is small, the Wolves appeared to select young and old deer as found elsewhere (Pimlott et al. 1969; Mech and Frenzel 1971; Fritts and Mech 1981).

In some cases, Wolves killed animals which were debilitated. A yearling bull Moose which was heavily infested with ticks and had removed much of its coat by rubbing was killed by Wolves during a cold spell (temperature near -35°C) during January 1980. Several Moose and Elk with relatively low BMF were killed by Wolves in our study. Examples include a yearling bull Moose with 10% BMF, one calf Moose and one 3.5 year male Moose with BMF levels below 11% and two female Elk (both calves) with BMF levels at 32% and 23% respectively. The occurrence of low BMF in the Simonette populations was unknown however, most individuals killed by Wolves had BMF greater than 20%; 23 Moose had an average

TABLE 3. Number and percent of Moose and Elk observed during early December on aerial transect surveys near the Simonette River, northwestern Alberta.

Species	1978	1979	1980	1981	Total (Mean)
Moose					
Bull	12 (10)	22 (14)	14 (8)	24 (14)	72 (12)
Cow	80 (67)	104 (66)	105 (62)	118 (69)	406 (66)
Calves	27 (23)	32 (20)	49 (29)	30 (18)	138 (22)
All cohorts	119	158	168	172	672
Elk					
Bull	2 (12)	3 (15)	9 (31)	—	14 (21)
Cow	9 (53)	11 (55)	9 (31)	—	29 (35)
Calves	6 (35)	6 (30)	11 (38)	—	23 (35)
All Cohorts	17	20	29	—	66

BMF level of 57% and eight Elk averaged 68% BMF.

Peterson et al. (1984) and Messier and Crete (1985) concluded that most Moose approaching death from malnutrition had < 20% bone marrow fat. Similarly, Franzmann and Arneson (1976) found moose with less than 10% BMF were near death from malnutrition. In that area of Alaska, Moose killed by accidents or Wolves averaged 69% BMF compared to 78% in interior Alaska (Gasaway et al. 1983). Clearly, the majority of Moose and Elk killed by Wolves in the Simonette area were not dying from malnutrition. Average percent BMF in this area appeared lower than reported in other studies (Fuller and Keith 1980; Carbyn 1983: Gasaway et al. 1983; Ballard et al. 1987) and this is difficult to explain considering the mild winters and a habitat of apparent high productivity in the Simonette area.

In addition to the kills of wild Cervidae, one feral horse, a mare, was killed by the Muskeg Lake Pack during winter (December 1979). Wolves in the study area did not scavenge extensively during winter, but took advantage of the few opportunities available. We observed radio-collared packs on five Elk and Moose carcasses that, upon inspection, were determined not to be Wolf kills. These included two cow Elk shot and abandoned by hunters and three Moose (2 cows, 1 bull) shot but not retrieved (probable cases of wounding). One Black Bear was fed on near its winter den we were unable to determine whether it was a case of predation or scavenging.

Impact of Wolf Predation

During the initial year of study, when Wolves were increasing rapidly (Table 1), Moose increased as well, but remained stable at about 1.3 Moose/km^2 during 1977-79 (Table 4). The apparent increase in the Moose population between the first two winters of our observations seems real because prior to our study, during 1972-75, when Moose were counted on the same quadrats, densities were 0.7-0.8/km^2. This increase in the Moose population to 1977 may be related to mild winters (except 1973-74) and earlier Wolf control in the area in 1972-73 and 1973-74.

Estimated Moose biomass during the period of highest Wolf populations, 1977-80, was 19-20 000 kg Moose/Wolf, well above that threshold when Wolf predation may be regulatory (Mech 1970; Fuller and Keith 1980; Hauge and Keith 1981; Bergerud et al. 1983; Gasaway et al. 1983). Mech concluded that at less than 11 000 kg prey/Wolf (equals about 30 Moose/Wolf) wolves may control Moose populations. A summary of relevant data (Gasaway et al. 1983) indicated that at 20 Moose/Wolf, predation will likely cause a decline, at 20-30 Moose/Wolf, predation can be the primary factor controlling a Moose population, and at > 30 Moose/Wolf, predation can be important, but is not likely to contribute to decline unless there are other significant sources of mortality. We recognize that the Wolf: prey ratio is only a general indicator to predation effect. Availability of alternate prey, especially other cervids, is important (Gauthier and Theberge 1987). Pimlott (1967) and Messier (1985) suggested that naturally-regulated Wolf-ungulate systems stabilize at low prey and predator densities.

Following experimental Wolf reduction from 39-40 to 13 during winter 1979-80 and from 15-16 to 3 during winter 1980-81, Moose calf ratios during December, 1980 and 1981 were not greater ($P > 0.05$) than before Wolf control. In fact, the lowest calf ratio (18%) was found in December 1981 when Wolf densities were lowest suggesting that factors other than Wolf predation were controlling recruitment that year. In addition, there was no detectable change in Moose populations following the Wolf reductions (Table 4). These observations suggest the Moose population at 56-71 Moose/Wolf was not regulated by Wolf predation during the study.

TABLE 4. Estimated numbers of Moose, Moose/Wolf, and Moose biomass/Wolf near the Simonette River, northwestern Alberta.

	Number of Moose Per			
Winter[a]	Quadrat[b] $\bar{x} \pm$ 95% CL)	Study Area[c]	Average Moose/Wolf	Estimated Moose Biomass (kg)/Wolf
1975-76	1.81 ± 0.63	964	64	22 000
1976-77	3.33 ± 0.92	1772	71	24 000
1977-78	3.51 ± 1.23	1870	57	20 000
1978-79	3.26 ± 0.90	1737	56	19 000
1981-82	3.18 ± 1.09	1694	—	—

[a]Surveys were not flown during 1979-80 and 1980-81 because of poor snow conditions.
[b]Quadrats were 1 mi^2; 43 were surveyed each year except for 1981-82, when 40 were surveyed.
[c]Moose survey area was 1380 km^2.

Deer, with a ratio of one Mule Deer: two White-tailed Deer (N = 285 observations during 1978-81) were not inventoried, so we have no estimates of densities. However, reports from local registered trappers and other residents suggested that deer increased markedly during a period of mild winters following mortalities associated with heavy snowfall during 1973-74, with a similar trend observed throughout the range of deer in northwestern Alberta (R. McFetridge, Regional Wildlife Biologist, Peace River, personal communication). Wolves killed younger and relatively old deer in our area, but apparently did not prevent the deer population from increasing.

The Elk population appeared stable or slightly increased during the 2-3 fold increase in Wolf numbers. Annual kills of bull Elk by hunters during the mid September-late November season averaged 20 during 1978-80 compared to 18 during 1974-76. Despite relatively few Elk/Wolf, apparent selection for Elk over Moose and selection for calves and prime aged cows, there was no obvious decline in Elk densities during this period of mild winters.

Although Wolf predation has been identified as the major source of mortality and a key contributor to population decline in some wild cervid populations, we did not observe that situation here. We relate the lack of regulatory predation in this instance to the diversity of prey, the abundance of Moose in habitat of apparent high productivity, to the mild winters and to a Wolf population that had not reached greatest possible density prior to the reinstatement of Wolf control in 1979-80.

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Population Ecology and Conservation of the Mountain Cottontail, *Sylvilagus nuttallii nuttallii*, in Southern British Columbia

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The Mountain Cottontail, *Sylvilagus nuttallii nuttallii*, in British Columbia is restricted to the Okanagan and Similkameen valleys where it is considered rare. A population in natural (sagebrush) and cultivated (tree fruit orchard) habitats was monitored on a 25.6-ha grid system near Summerland, B.C. The density of cottontails varied from 42.5 (1984) to 22.5 (1985 and 1986) per 100 ha of sage habitat. Few cottontails were captured in the orchard habitat. Fecal pellet counts indicated that sagebrush habitats with at least 30% vegetative cover represented good habitat for cottontails.

Key Words: Mountain Cottontail, *Sylvilagus nuttallii nuttallii*, conservation, Okanagan and Similkameen valleys, sagebrush habitat, orchard.

The Mountain Cottontail, *Sylvilagus nuttallii nuttallii*, has been reported only from the arid Okanagan and Similkameen valleys of southern British Columbia (Cowan and Hatter 1940; Cowan and Guiguet 1966). A related subspecies, *S. n. grangeri*, occurs in the southern parts of the prairie provinces (Banfield 1974). This lagomorph is clearly a peripheral species in Canada with a more extensive distribution within the western and central Great Plains of the United States. *Sylvilagus n. nuttallii* is considered rare in B.C. and is protected under the Wildlife Act, but there have been no confirmed records in the Okanagan or Similkameen valleys in recent years (Wildlife Branch, Penticton, B.C., personal communication). The species was abundant enough to be classified as a pest to horticultural production and was controlled with poison baits from 1955 until about 1965. There have been no reports of rabbit damage to agriculture in these areas in the last 10 to 15 years.

There are two major factors which may have affected the distribution and abundance of this species. First, intensive tree fruit and cultivated crop production as well as livestock grazing have greatly reduced available habitat in these southern valleys. In addition, the intensive use of pesticides in tree fruit and market garden production may have adversely affected cottontail populations near or in cultivated areas. There is no information available on the occurrence of these animals in orchards.

This study was to determine (1) the population dynamics of the Mountain Cottontail in natural and orchard habitats and (2) its distribution in a variety of habitats in the Okanagan and Similkameen valleys. This information was used to plan a conservation strategy for this species in B.C.

Study Areas

An intensive study area for monitoring cottontail populations was established in cultivated and natural habitats at the Agriculture Canada Research Station, Summerland, B.C. The cultivated habitat was composed mainly of apple orchards with some cherry and pear orchards, a vineyard, and ungrazed old fields. The natural habitat was composed of Big and Small sagebrush (*Artemisia tridentata* and *A. tripartita*, respectively) with some Ponderosa Pine (*Pinus ponderosa*) and Douglas Fir (*Pseudotsuga menziesii*). Other components of the vegetation included Pinegrass (*Calamagrostis rubescens*), Bunchgrass (*Festuca idahoensis*), Serviceberry (*Amelanchier alnifolia*), Snowberry (*Symphoricarpos albus*), Oregon Grape (*Berberis nervosa*), and knapweed (*Centaurea diffusa* and *C. maculosa*). This study area was in the Ponderosa Pine — Bunchgrass Biogeoclimatic Zone (Krajina 1969).

Four additional geographic regions or valleys were identified for study of the distribution of cottontails in the Okanagan and Similkameen valleys (Figure 1). Within each region, the following habitats (if present) were sampled:

1 — Big Sagebrush
2 — Mixed sagebrush
3 — Small Sagebrush

4 — Grassland (natural)
5 — Small Sagebrush/rock outcrops
6 — Riverine (riparian)
7 — Ponderosa Pine parkland
8 — Douglas Fir open forest
9 — Lodgepole Pine (*Pinus contorta*) montane forest

Materials and Methods

Population Dynamics

A 25.6-ha grid was established in the cultivated and natural habitats at the Summerland Research Station. A total of 232 trap stations were located at 30-m intervals with one live trap (23 × 23 × 80 cm) at every other station. This grid was trapped for two or three nights every three weeks from May to October 1984, April to September 1985, and April to August 1986. Trapping during the 1984-85 winter was conducted at 4- to 12-week intervals. Traps (baited with apples and alfalfa cubes) were set on the afternoon of day 1, checked on the morning and afternoon of day 2 (and 3) and morning of day 3 (and 4) and then locked open between trapping periods. All rabbits captured were ear-tagged with individually numbered metal tags, and species, age, sex, reproductive condition, weight and point of capture were recorded. Information on breeding condition was determined by palpation of male testes and by observation of the mammaries of the females. Recruits were defined as new animals which entered the population. Population estimates used minimum number of animals known to be alive (MNA) (Krebs 1966) at a given trapping period to compare densities between the two habitats.

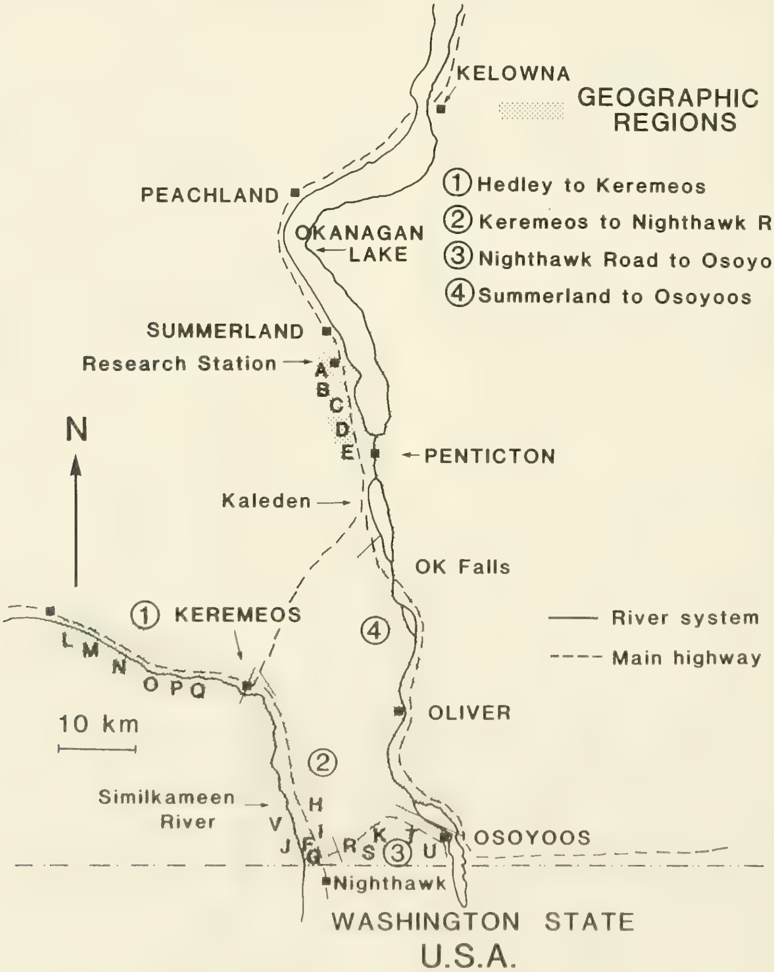

FIGURE 1. Study areas for Mountain Cottontails in the Okanagan and Similkameen valleys. Habitats sampled by pellet transects are indicated by letters, see Tables 2, 3, and 4.

Pellet Counts

Estimates of habitat use by rabbits were obtained from fecal pellet counts on a series of permanent circular plots. Individual plots of 1.8 m^2 (0.00018 ha) were arranged in transects, with each transect consisting of 10 stations spaced at 30-m intervals. Each station had a pair of plots with centers 1.5 m on each side of the transect center line. This technique was modified after that of Wolfe et al. (1982).

Fecal pellets were counted and removed at the initial sampling on each transect. Each of the 18 trap-lines on the grid system was treated as a transect. Lines A to O compared use of cultivated versus natural habitats by cottontails with two plots at every other station. Lines N, O, P, Q, and R from stations 4 to 13 represented standard 10-station transects (habitats A, B, C, D, and E) for comparison with other natural habitats. In addition, a transect was established and sampled in each of the habitats (F to K in 1984 and L to V in 1985) outlined in Figure 1. All sampling was conducted during May to September 1984 and May to August 1985. All pellet counts from the grid plots provided an assessment of the current use patterns when sampled in consecutive years. Pellet counts in additional habitats represented the historical pattern of habitat use by rabbits.

Vegetation Cover

The vegetation in each habitat sampled by a pellet transect was assessed by individual 5-m^2 circular plots located at each of the ten stations on a transect. The species of dominant vegetation (e.g. Big sagebrush, Bunchgrass) were recorded and the estimated percentage of ground cover (i.e. cover for a rabbit) stratified in classes of:

Class	%
(0)	0
(1)	1-20
(2)	21-40
(3)	41-60
(4)	61-80
(5)	81-100

Results

Population Dynamics

We captured and tagged 62 individual Mountain Cottontails between May 1984 and August 1986. The population density in the 19.7 ha of sage habitat during this period is outlined in Figure 2. Minimum unweighted trappability (Krebs and Boonstra 1984) was 0.60 (n = 11) with minimum number alive representing density changes in this study (Hilborn et al. 1976).

In 1984, the early summer density of 5 animals increased to a peak of 15 cottontails by late

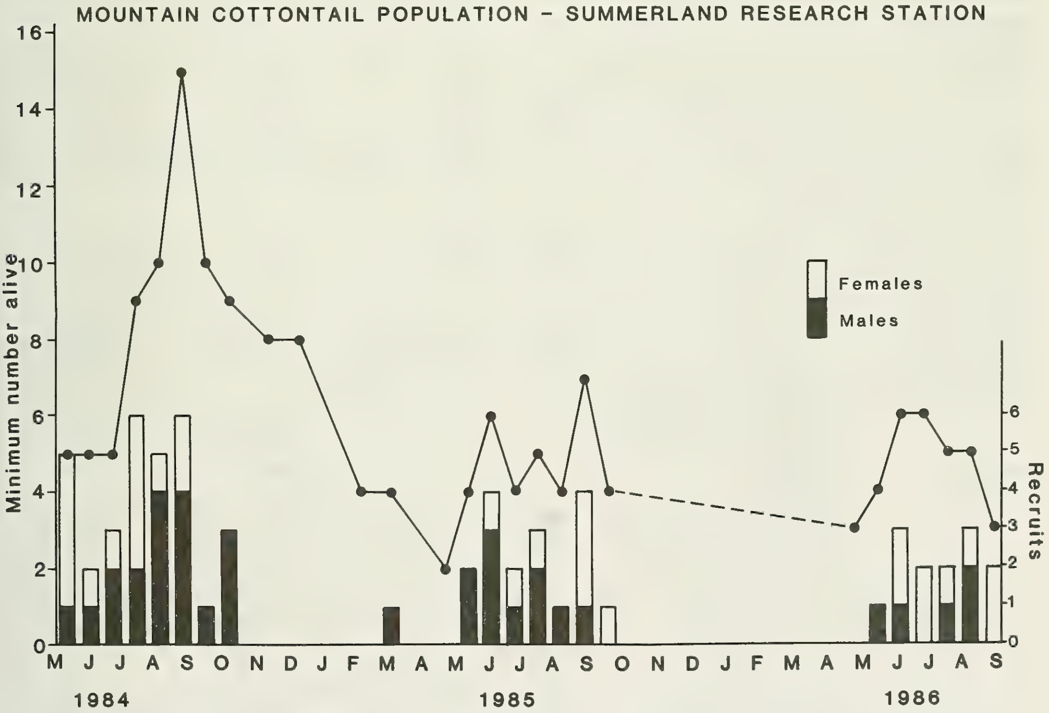

FIGURE 2. Population density and recruitment of Mountain Cottontails at the Summerland Research Station during May 1984 to August 1986.

TABLE 1. Survival (or residency) rates (per 21 days) of Mountain Cottontails on the 19.7-ha grid at the Summerland Research Station. Sample size in parentheses. a-a, b-b, $p < 0.05$; c-c, d-d, $p < 0.01$; significant difference by chi-square. e-e ($p = 0.065$) f-f ($p = 0.077$)

Period	Males	Females	Total
Summer 1984 (May-October)	0.50 (24)	0.50 (20)[a]	0.50 (44)
Winter 1984-85 (November-March)	0.49 (11)[e]	0.87 (10)[ae]	0.67 (21)[bd]
Summer 1985 (April-September)	0.00 (11)[c]	0.56 (9)[c]	0.25 (20)[d]
Winter 1985-86 (October-March)	0.00 (0)	0.00 (1)	0.00 (1)
Summer 1986 (April-August)	0.00 (3)	0.30 (10)	0.23 (13)[b]
Total	0.35 (49)[f]	0.53 (50)[f]	0.45 (99)

August. This increase reflected a pulse of juvenile (70% of population) recruitment during July and August. The number of cottontails declined to 8 animals during the fall and early winter. Only one cottontail was captured in the 5.9 ha of cultivated (orchard) habitat and this was at a station approximately 30 m from the nearby sage habitat.

Density of cottontails averaged 4 to 5 individuals per trapping week throughout 1985 and 1986, approximately one-third the abundance recorded during 1984. This decline might be related to the very dry summer which could have restricted growth of herbaceous vegetation, an important seasonal food source for cottontails. No other lagomorph species were captured on this grid. However, Bushy-tailed Woodrats (*Neotoma cinerea*) and the Yellow-bellied Marmot (*Marmota flaviventris*) were also captured in the sage habitat.

The 1984 breeding season was in progress at the start of the study and continued up to mid-July. The 1985 and 1986 breeding seasons began in March and continued to July. Causes of the disappearance of animals from the trappable population included both mortality and emigration. Summer and winter survival rates are measured by direct enumeration and are given in Table 1. In general, females survived significantly better than males and winter survival of cottontails in 1984-85 was significantly higher than in either of the subsequent summers.

The sex ratio (proportion of males) of this population was estimated from the minimum number alive, and these data were summed for each year. This ratio varied from 0.57 (n = 84) in 1984 to 0.44 (n = 45) in 1985 to 0.16 (n = 32) in 1986. This very low proportion of males in 1986 was significantly different (Chi-square, $p < 0.01$) from those values in the two previous years.

Distribution

Pellet densities in the two habitats on the grid system are listed in Table 2 (1984) and Table 3 (1985). Clearly, cottontails avoid use of the cultivated habitat and this pattern is also supported by the distributional data obtained by

TABLE 2. Mountain Cottontail pellet densities (mean number/0.00018 ha) in natural and cultivated habitats on the grid system at Summerland Research Station, and rabbit pellet densities in natural habitats in other localities, 1984. Habitat location in parentheses; see Figure 1.

Study area	Habitat		Average ground cover class	Mean (± SE)	Sample size (no. of plots)
Grid system	Mixed sagebrush-Ponderosa Pine parkland		–	118.5 ± 18.9	103
	Orchard/old field			2.8 ± 1.8	56
Summerland	Big Sagebrush	(A)	1.7	38.7 ± 16.1	20
	Mixed sagebrush	(B)	1.8	0.7 ± 0.6	20
	Grassland-sage	(C)	1.7	17.3 ± 7.7	20
	Mixed sagebrush	(D)	1.5	242.0 ± 106.7	20
	Small Sagebrush	(E)	1.1	117.4 ± 70.0	20
Keremeos-Nighthawk	Big Sagebrush	(F)	1.6	14.7 ± 7.1	20
	Small Sagebrush-rock outcrop	(G)	1.5	43.3 ± 15.3	20
	Grassland	(H)	0.2	0.0 ± 0.0	20
	Small Sagebrush	(I)	1.3	3.5 ± 1.8	20
	Ponderosa Pine	(J)	0.8	0.1 ± 0.1	20
Nighthawk-Osoyoos	Grassland	(K)	0.1	0.0 ± 0.0	20

TABLE 3. Mountain Cottontail pellet densities (mean number/0.00018 ha) in natural and cultivated habitats on the grid system at Summerland Research Station, and rabbit pellet densities in natural habitats in other localities, 1985. Habitat location in parentheses; refer to Figure 1.

Study area	Habitat		Average ground cover class	Mean (± SE)	Sample size (no. of plots)
Grid system	Mixed sagebrush-Ponderosa Pine parkland		—	41.1 ± 7.5	94
	Orchard/old field		—	3.5 ± 2.1	56
Summerland	Big Sagebrush	(A)	1.7	36.3 ± 11.8	20
	Mixed sagebrush	(B)	1.8	0.6 ± 0.4	20
	Grassland-sage	(C)	1.7	30.6 ± 12.0	18
	Mixed sagebrush	(D)	1.5	122.1 ± 52.5	20
	Small Sagebrush	(E)	1.1	45.9 ± 24.7	20
Keremeos-Nighthawk	Big Sagebrush	(F)	1.6	12.9 ± 5.7	20
	Small Sagebrush-rock outcrop	(G)	1.5	17.8 ± 8.0	20
	Grassland	(H)	0.2	0.0 ± 0.0	20
	Small Sagebrush	(I)	1.3	0.3 ± 0.3	20
	Ponderosa Pine	(J)	0.8	0.1 ± 0.1	20
Nighthawk-Osoyoos	Grassland	(K)	0.1	0.0 ± 0.0	20

live-trapping. The distribution of Mountain Cottontails according to pellet densities at other sampled localities is given in Tables 2, 3, and 4. These rabbits clearly prefer sagebrush habitats. The only exception was the mixed sagebrush at Summerland, which was associated with a deep gully. This gully (and others on the grid system) were regularly used by Coyotes (*Canis latrans*) and so it is not surprising that little activity by rabbits was recorded in these areas.

Discussion

The Mountain Cottontail continues to be resident in the Okanagan and Similkameen valleys of southern British Columbia. The population density of cottontails at Summerland varied from 42.5 (1984) to 22.5 (1985 and 1986) per 100 ha of sage habitat. This range of abundance is within that (6.6 to 254.4/100 ha) recorded by McKay and Verts (1978a) in shrub-juniper scrubland of central Oregon.

The preference by Mountain Cottontails for habitats dominated by sagebrush on the Summerland grid and in other areas was similar to that reported for this species in different parts of the western United States (Dice 1926; Orr 1940; Ingles 1965; Chapman 1975; McKay and Verts 1978b). Pellet counts indicated that the use of other habitat types is very low or non-existent.

Although cultivated habitats appear to lack cottontails, the irrigation associated with cultivation in these semi-arid valleys may in fact

TABLE 4. Accumulated rabbit pellet densities on uncleared plots in natural habitats, 1985. Habitat location in parentheses; refer to Figure 1.

Study area	Habitat		Average ground cover class	Mean (± SE)	Sample size (no. of plots)
Hedley to Keremeos	Grassland	(L)	0.6	0.0 ± 0.0	20
	Small Sagebrush-rock outcrop	(M)	0.7	0.0 ± 0.0	20
	Lodgepole Pine forest	(N)	1.5	35.2 ± 10.8	19
	Douglas Fir	(O)	0.3	1.2 ± 0.5	20
	Mixed sagebrush	(P)	1.0	0.0 ± 0.0	20
	Riparian	(Q)	2.6	10.8 ± 2.5	20
Nighthawk to Osoyoos	Small Sagebrush	(R)	1.2	0.0 ± 0.0	20
	Small Sagebrush-rock outcrop	(S)	1.2	2.2 ± 1.1	20
	Ponderosa Pine	(T)	0.2	4.1 ± 1.1	20
	Big Sagebrush	(U)	1.9	22.6 ± 7.5	20
Keremeos-Nighthawk	Riparian	(V)	1.6	2.3 ± 1.2	20

provide a source of herbaceous forage for cottontails residing in nearby sagebrush areas. The importance of succulent forage for survival of young cottontails during summer drought was noted by McKay and Verts (1978a). Both 1985 and 1986 had dry summer periods compared with 1984 and this may possibly explain the decline in density of cottontails in our study.

The Eastern Cottontail (*S. floridanus*) was first introduced into eastern Washington in 1926 (Dalquest 1941). This species was able to expand its range after introduction (Anderson 1940; Dalquest 1941; Verts et al. 1972) and may have an adverse effect on native populations of the Mountain Cottontail (Genoways and Jones 1972; Chapman 1975). The Eastern Cottontail had spread into the Lower Fraser Valley by 1950 (Kluge and Weber 1986) and could eventually reach the Okanagan and Similkameen valleys.

The complete lack of captures or observations of White-tailed Jackrabbits (*Lepus townsendii townsendii*) suggests that this species has not adapted well to loss of habitat in these southern valleys. Although the presence of jackrabbits in sagebrush habitats cannot be completely ruled out on the basis of pellet transects, it is unlikely that the species is able to maintain itself in these areas.

The Mountain Cottontail is currently protected from hunting in B.C. The establishment of land reserves to protect critical habitat could further promote the survival of this subspecies in B.C. The choice of sagebrush habitats with at least 30% vegetative cover is recommended on the basis of this study.

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Foraging Activity of Bumble Bee, *Bombus* spp., Workers on Yellow Hedysarum, *Hedysarum sulphurescens*, in a Subalpine Meadow

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The diel activity of bumble bee workers foraging on *Hedysarum sulphurescens* Rybd. (Leguminosae) in a subalpine meadow was studied in relation to ambient temperature and nectar production. Foraging activity was significantly temperature-dependent for all seven *Bombus* species observed in the meadow. Workers of *B. mixtus* were significantly smaller than those of *B. melanopygus* and *B. sylvicola* and showed a greater temperature dependence because of a higher cost of thermo-regulation at low temperatures. Sugar concentration in nectar varied from 22% to 95% sucrose equivalents and was inversely related to humidity. The activity of *B. melanopygus* and *B. sylvicola* workers was significantly, though weakly, correlated with sugar concentration; however, the activity of *B. mixtus* workers was not. Therefore, of the variables examined, temperature was the most important factor influencing foraging activity of the bumble bee workers.

Key Words: Bumble bees, *Bombus*, body size, foraging, temperature, *Hedysarum sulphurescens*, nectar production, Alberta.

The foraging activity of bumble bee workers, *Bombus* spp., varies during the day and shows peak activity around noon (Teras 1976; Allen et al. 1978; Corbet 1978) or a bimodal pattern with peaks in the morning and afternoon (Roberts 1979; Corbet et al. 1979). An increased cost of foraging at low temperatures has been invoked as an explanation for the low abundance of bumble bees early in the day (Richards 1973; Lundberg 1980; Heinrich and Heinrich 1983; Bowers 1986). The reasoning is that at low ambient temperatures bees must expend more energy to maintain their thoracic muscles within the 30°C to 44°C range necessary for flight (Heinrich 1979) than at high ambient temperatures.

Diel variation in bee visits to flowers has also been attributed to changes in the concentration and quantity of nectar available. Corbet et al. (1979) found that bumble bee visits to *Echium vulgare* and *Tilia* spp. peaked when the sugar concentration of the nectar reached 45% sucrose equivalents then decreased during the middle of the day when the concentration rose to 55%, presumably causing the nectar to become more viscous. Small volumes of nectar (Heinrich 1976) or a decrease in the number of available nectar-producing flowers (Pleasants 1981) may also cause changes in foraging activity.

Previous studies have, in general, focused on the role of either nectar availability or physical factors such as temperature on bumble bee foraging, but not on both simultaneously. In this paper, we analyse the activity of bumble bee workers foraging on Yellow Hedysarum, *Hedysarum sulphurescens* (Leguminosae), in relation to nectar production and ambient temperature.

In many plants, sugar concentration in nectar is partially determined by post-secretory equilibration with ambient humidity (Corbet et al. 1979; Plowright 1981) and tends to decrease with increasing humidity. The concentration may also depend on temperature, generally increasing as temperature increases (Percival 1965). The quantity of sugar contained in the standing crop of nectar depends on the volume secreted, the concentration, and the rate at which it is depleted by foraging insects. Given these complex relationships, we describe the influence of humidity and temperature on the diel pattern of nectar production by Yellow Hedysarum.

Bumble bees are efficient thermo-regulators, and prior to flight they generate heat in the thorax by shivering their flight muscles, which they uncouple from the wings (Heinrich 1979). During flight the thorax is maintained at or near the optimum temperature by a balance between heat production by the muscles and heat loss, which occurs mainly through the abdomen (Heinrich 1979). Cooling rate depends on ambient temperature and body mass (Heinrich and Heinrich 1983).

Bumble bees of all sizes (65 mg to 830 mg) maintain similar thoracic temperatures in the field; however, small bees have higher passive cooling rates than larger bees (Heinrich and Heinrich

1983). This means that small individuals have to expend more energy than larger individuals when foraging at low ambient temperatures. The foraging activity of smaller bees should therefore be more dependent on temperature than that of larger bees. Indeed, Heinrich and Heinrich (1983) found that the foraging activity of queens was much less temperature-dependent than that of workers.

We tested the following two predictions. The first is that activity should increase with increasing temperature because of the high energetic cost of foraging at low ambient temperatures. The second is that species with workers of large body size should show significantly less temperature dependence than those with workers of small body size.

At all times bees must obtain sufficient fuel — sugar in nectar — to power their muscles. Therefore, we also examine the relationship between foraging activity and sugar concentration and quantity in nectar. We postulate that humidity is inversely related to temperature and sugar concentration is in turn inversely relation to humidity, in which case sugar concentration and total sugar would both be positively correlated with temperature, as is foraging activity. If temperature positively influences both activity and the nectar variables, a positive correlation between activity and the nectar variables would be spurious. If an increase in temperature causes an increase in foraging activity as well as an increase in sugar concentration, a positive correlation between the latter two would occur. Clearly, this would also not imply that the bees were increasing their activity in response to the increase in concentration.

Materials and methods

Sampling was carried out on five days from 16 to 25 July 1986 in a subalpine meadow at an elevation of about 1980 m in the Kananaskis Mountain range (50° 58′ N, 115° 00′ W) of the southern Canadian Rockies in western Alberta. During the study period the only forage plant available was *H. sulphurescens,* which occurred at high densities in the meadow. Yellow Hedysarum is a perennial herb 30-60 cm tall, usually with many flowers per raceme. It is often found along stream banks or in woods but occasionally in subalpine or alpine sites (Scotter and Flygare 1986).

Bumble bee activity

Three study plots (10 m × 10 m) were placed at random within the meadow. This was done by drawing a grid on a topographic map of the meadow and then picking three squares using a table of random numbers. We visited each plot at 30 min intervals and counted the number of bumble bees present during a visual sweep of the plot.

Environmental conditions

Temperature and humidity were also measured at 30 min intervals using a Fisher Digital Hygrometer (model H64). The readings were taken at the same location each day about 1 m above the ground, with the probe shaded from direct sunlight.

Nectar measurements

A sample of three to five flowers of *H. sulphurescens* was collected at 30 min intervals within a 1 m radius of a location in the meadow selected at random (using the same method as for the selection of study plots). The flowers on a single raceme blossom in sequence from the top down with the oldest flower at the top of the plant. Only flowers at the same stage (with pollen still present on the stamens) and approximately the same age were selected for nectar measurement. Nectar was extracted using a 2 μl Drummond micropipette, and the volume removed from each flower was estimated from the depth (measured in mm using a ruler) to which the micropipette was filled. Nectar from the sampled flowers was collected in the same micropipette and the sugar concentration was measured, after dilution if necessary, with a Bellingham and Stanley pocket refractometer (0-50% range). The concentration (sucrose equivalent) recorded is the average for the sample of flowers. The amount of available sugar (mg) in the nectar per flower was calculated using the average concentration and the estimated volume per flower, giving a mean and standard error.

Body size

Workers of *B. mixtus* and *B. melanopygus* collected from the study meadow (and adjacent meadows) were measured for glossa length (the functional length of the proboscis) and the length of the radial-cell of the wing. Glossa length was measured using the method of Harder (1982). The right forewing of each bee was removed and placed between two microscope slides in a Kodak Trimlite F microfiche reader. The length of the radial-cell was measured directly from the screen and adjusted for the magnification used. Glossa length and radial-cell length are highly correlated (Medler 1962; Harder 1982), and glossa length has a significant positive correlation with body mass in worker bumble bees (Harder 1985). Radial-cell length only was measured for field-collected workers of *B. sylvicola.*

Results

Plant density

The density of *H. sulphurescens* in the meadow was generally high and the plants were quite uniformly distributed. The total number of plants (racemes) in each of the three study plots was 2011, 2220 and 3024, representing a density of 20.11, 22.20 and 30.24 per m², respectively. Each raceme had from six to ten flowers in bloom.

Nectar production

Sugar concentration in nectar varied from 22% to 95% sucrose equivalents during the study period. Fluctuations over this range occurred on a diel basis on some occasions. Figure 1 shows nectar production in relation to ambient humidity and temperature on 19 July. Sugar concentration increased during the day as humidity decreased; a similar though less pronounced trend was also apparent for volume and total sugar. Both showed considerable fluctuation, no doubt reflecting intrinsic variation between flowers as well as measurement error. The amount of sugar per flower did not show any overall trend during the study period (Table 1) and, given a high density of plants, resources were apparently abundant.

The correlations between environmental variables and nectar production for the data pooled over all study days are given in Table 2. Both sugar concentration in nectar and total sugar/flower are influenced by humidity and temperature. We can postulate a causal pathway connecting temperature, humidity and sugar concentration; humidity is inversely related to temperature, and in turn sugar concentration is inversely related to humidity, thus leading to a positive correlation between temperature and concentration (Table 2).

Bombus species composition

Workers of seven *Bombus* species (*occidentalis, bifarius, flavifrons, frigidus, melanopygus, mixtus, sylvicola*) occurred in the meadow during the study period. The last three accounted for more than 80% of the total abundance (Table 3). Workers of *B. melanopygus* and *B. sylvicola* are of similar size (see below) and can be distinguished only by the amount of yellow pile on the scutum anterior to the tegulae (Stephen 1957), which in this Alberta location, as in British Columbia, is a continuous character. Hence, in our analyses of foraging activity the data for *melanopygus* and *B. sylvicola* have been pooled.

Body size

The mean radial-cell lengths of the three predominant species in the meadow are given in Table 4. Homogeneity of sample variances was tested using Bartlett's test (Sokal and Rohlf 1981) and no significant heteroscedasity was found (adj $x^2 = 3.94$, 2df, $P > 0.05$). However, there are significant differences between some of the means (one-way ANOVA, $F = 30.59$, $P < 0.001$).

The mean radial-cell lengths of *B. melanopygus* and *B. sylvicola* do not differ significantly ($P > 0.05$), but both these species have significantly greater ($P < 0.05$) means than that of *B. mixtus* (GT2 unplanned comparison method, Sokal and Rohlf 1981). Also the mean glossa length of *B. melanopygus* (4.63 ± 0.068 mm, n = 6) is significantly greater ($P < 0.001$) than that of *B. mixtus* (3.79 ± 0.077 mm, n = 18). We conclude that workers of *B. melanopygus* and *B. sylvicola* are of similar average body size; both are

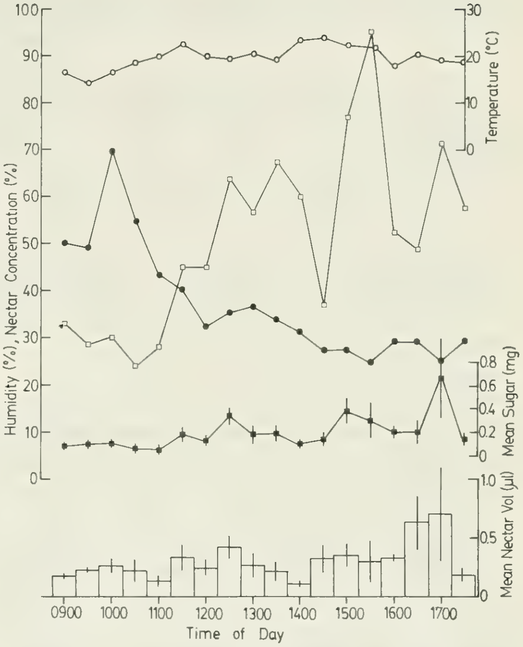

FIGURE 1. Production of nectar by *Hedysarum sulphurescens* on 19 July 1986 in relation to changes in ambient humidity and temperature. Shown are temperature (○), humidity (●), mean sugar concentration in nectar (□), mean amount of sugar (mg) per flower (± one standard error) (■), and mean volume of nectar (± 1 S.E.) (histogram).

TABLE 1. Mean (± standard error) sugar concentration in nectar (sucrose equivalent), nectar volume and quantity of sugar per flower of *Hedysarum sulphurescens* on each of the study days.

		Nectar		
July	n	concentration (%)	volume (µl)	sugar (mg)
16	57	39.3 ± 15.1	0.40 ± 0.32	0.15 ± 0.01
18	39	41.2 ± 7.3	0.19 ± 0.16	0.09 ± 0.01
19	82	51.2 ± 18.9	0.30 ± 0.27	0.17 ± 0.03
22	67	28.7 ± 4.7	0.32 ± 0.25	0.10 ± 0.01
25	50	51.9 ± 16.4	0.14 ± 0.13	0.01 ± 0.01

TABLE 2. Correlations between environmental variables and nectar production in *H. sulphurescens* for the data pooled over all study days (n = 68 observations). Product-moment correlation coefficients (r) are given.

	Humidity	Sugar concentration	Amount of sugar (mg)	Nectar volume
Temperature	-0.802****	0.320****	0.262*	—
Humidity		-0.534****	-0.308****	0.106 ns

*$P < 0.05$, **$P < 0.02$, ***$P < 0.01$, ****$P < 0.001$, ns — not significant.

significantly larger than workers of *B. mixtus*. Radial-cell length and glossa length are positively correlated in *B. mixtus* ($r = 0.56$, $P < 0.05$) and *B. melanopygus* ($r = 0.67$, $0.1 > P > 0.05$).

Foraging activity

We observed a gradual increase in the number of bees foraging during the morning hours, followed by relatively steady activity throughout the rest of the day until a decline at dusk. Foraging ceased soon after the onset of heavy rain, but bees continued to forage in drizzle or light rain (Figure 2). Foraging activity was temperature-dependent for all species. There was a significant linear relationship between the total number of bees (of all seven species) and temperature for the data pooled over all study days (68 observations), given by the regression equation, Number of bees = -1.53 + 1.13 x Temperature (°C) ($F = 35.6$, $P < 0.001$).

We tested the prediction that the larger species (*B. melanopygus* and *B. sylvicola*) would show less temperature dependence than the smaller species (*B. mixtus*). We expected the foraging activity of the larger species to be less affected by changes in ambient temperature than that of the smaller species, and tested this by comparing the slopes of the regressions (number of bees on ambient temperature) calculated for the two sizes of bees (Figure 3). The slope of the regression equation for *B. mixtus* ($b = 0.575 \pm 0.125$) is significantly steeper than that for *melanopygus* and *sylvicola* ($b = 0.266 \pm 0.068$) ($t = 3.03$, $P < 0.005$). This indicates that the foraging activity of *B. mixtus* workers in this meadow is significantly more affected by changes in ambient temperature than is the foraging activity of *B. melanopygus* and *B. sylvicola* workers.

The relationship between foraging activity and nectar variables (Table 5) indicates that foraging activity of *B. mixtus* is correlated with neither sugar concentration nor total sugar in nectar. However, the activity of *B. melanopygus* and *sylvicola* appears to be, if only simple correlations are considered (Table 5). These relationships bear closer examination as we have already shown (Table 2) that concentration and total sugar are both positively correlated with temperature (through a postulated causal pathway involving humidity), as is foraging activity. Therefore, if temperature positively influences both activity and the nectar variables, then a positive correlation between activity and the nectar variables may well be spurious. That is to say, if an increase in temperature causes an increase in foraging activity as well as an increase in sugar concentration, then a positive correlation between the latter two would occur. Clearly, this would also not imply that the bees were increasing their activity in response to the increase in concentration. To determine if there is a true correlation between activity and the nectar variables independent of temperature, partial correlations are also given in Table 5. A partial correlation coefficient measures the correlation between two variables when other variables (in this case temperature) are held constant (Sokal and Rohlf 1981). The partial correlations show that the activity of *B. melanopygus* and *B. sylvicola* is not significantly correlated with total sugar but is significantly correlated with concentration, as the

TABLE 3. Total number of bumble bee workers observed on each study day and the percentage accounted for by three species.

July	Sampling period (h)	Number	Species of *Bombus* (%)			
			mixtus	*sylvicola*	*melanopygus*	others
16	7.5	229	55.0	17.0	12.7	15.3
18	5.5	218	61.0	16.0	6.0	17.0
19	8.5	354	57.0	10.7	15.0	17.3
22	6.5	85	61.0	14.1	9.4	15.5
25	5.0	137	51.0	21.1	10.2	17.7

TABLE 4. Radial-cell lengths of the three predominant species of bumble bees found in the meadow.

		Radial-cell length (mm)		
Bombus species	n	x̄	S.E.	Range
mixtus	18	2.41 ± 0.029		2.15 - 2.67
sylvicola	9	2.68 ± 0.055		2.55 - 2.98
melanopygus	6	2.83 ± 0.026		2.73 - 2.91

observed value of r (0.242) barely exceeds the critical value of $r_{0.05(2),\ 66} = 0.239$.

Discussion

Of the variables examined, temperature was the most important factor influencing the foraging activity of the worker bumble bees in the subalpine meadow. This corresponds with the results of other studies at low elevations (Heinrich and Heinrich 1983), alpine (Lundberg 1980) and arctic (Richards 1973) sites. Perhaps the most interesting result is that we confirmed a prediction that species of different body sizes showed significantly different dependence on temperature for foraging activity. Bees of small body size are expected to be influenced by ambient temperature to a greater extent than those of larger size, because of a greater cost of foraging at low temperatures. Workers of *B. mixtus* were significantly smaller than those of *B. melanopygus* and *B. sylvicola*, and showed a significantly greater dependence on temperature for foraging activity.

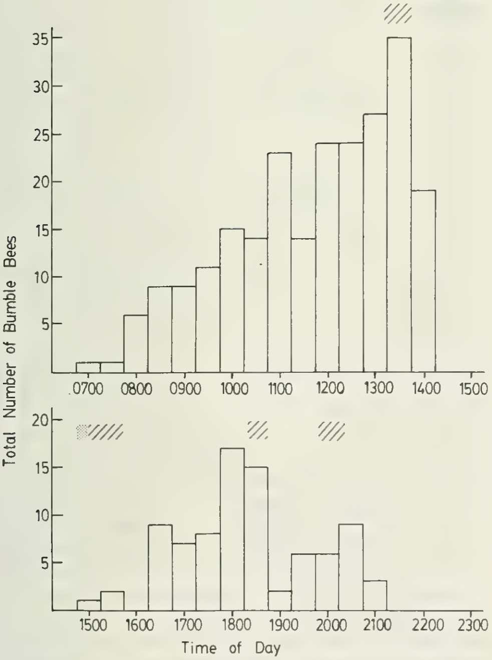

FIGURE 2. Foraging activity of bumble bee workers on 16 July (top) and 22 July (bottom). Activity ceased during heavy rain (represented by stippling) but continued during light rain showers (cross hatching).

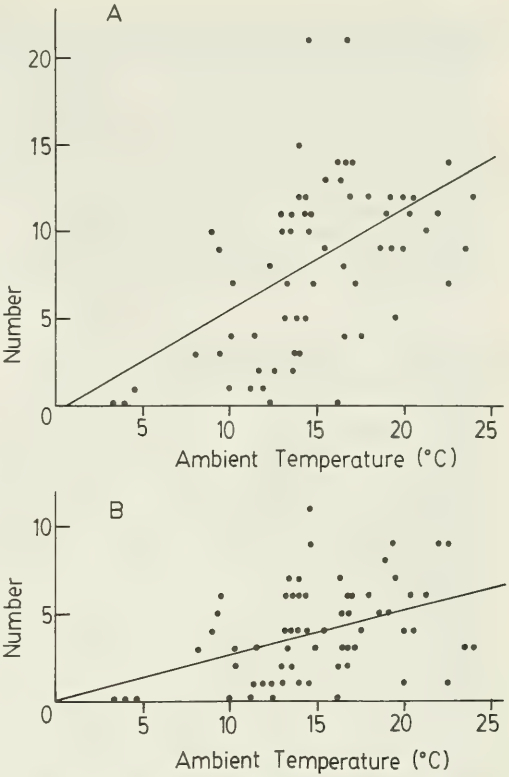

FIGURE 3. Relationship between number of bumble bee workers foraging and ambient temperature for the data pooled over all study days. A: *B. mixtus*. The regression equation is Number = -0.20 + 0.575 Temperature (°C) (F = 21.08, P < 0.001). B: *B. melanopygus* and *B. sylvicola* (data for both species pooled); the regression equation is: Number = -0.01 + 0.266 Temperature (°C) (F = 15.22, P < 0.001).

Although nectar production by Yellow Hedysarum was variable, the average concentration of sugar and quantity were generally high (Table 1), and there was no indication that nectar resources were limiting for the bumble bees at that time of the season. However, sugar concentration was strongly influenced by ambient humidity, which in turn depended upon temperature. This resulted in a positive correlation between concentration and temperature.

The foraging activity of *B. mixtus* workers was correlated with neither sugar concentration nor

TABLE 5. Simple and partial correlation coefficients between numbers of bumble bees and temperature and nectar variables for the data pooled over all study days (n = 68 observations).

	Species		
	B. mixtus	*B. melanopygus* / *B. sylvicola*	
Variables	r(simple)	r(simple)	r(partial)
Temperature (°C)	0.492****	0.433****	
Concentration (%)	0.092 ns	0.345***	0.242*
Sugar (mg)	0.156 ns	0.292**	0.205 ns

*P < 0.05, **P < 0.02, ***P < 0.005, ****P < 0.001, ns — not significant.

quantity. In contrast, there was a correlation, albeit only just statistically significant, between concentration and the activity of *B. melanopygus* and *B. sylvicola* workers. One plausible interpretation of these results is that the larger species (*B. melanopygus* and *B. sylvicola*), being less constrained by temperature for foraging, can afford to respond to changes in sugar concentration, while *B. mixtus*, under greater temperature constraints, cannot.

The absence of a strong association between bee activity and sugar concentration in nectar is not surprising. Most sugar concentrations lay in the range of 30% to 70% (Table 1) during the study period, and flowers were very abundant. The sucrose concentration predicted to maximize a bee's rate of net energy uptake is 50% to 60%, although ingestion rate decreases due to greater viscosity with solutions more than 35% to 40% sucrose (Harder 1986). Given the high abundance of resources, it seems to be unlikely that bees would respond in a major way to relatively minor fluctuations in sugar concentrations around the values observed.

In this subalpine meadow, as is the case in alpine (Lundberg 1980) and arctic regions (Richards 1973), physical factors, particularly temperature and rain, limit the foraging activity of bumble bee workers. Also, as we have shown, some species may be affected by temperature to a greater extent than others because of differences in body size. However, we cannot draw any conclusions from these observations about the relative competitive ability of the species and the ultimate effects on abundance.

There are undoubtedly many factors that influence the relative abundance of species of bumble bees. Bowers (1985) has proposed that stochastic processes are important in subalpine meadows. He suggests that species' composition depends on the number of queens of each species that disperse into a meadow in the spring and their success in establishing colonies that produce workers and survive long enough to yield reproductives. Thus, in the meadow, *B. mixtus* may be abundant one year but rare the next, and how successful it is in one season may not affect its abundance in the same meadow the following season.

Acknowledgments

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Comparative Phenology of Some Alpine Vascular Plant Species on Lakeview Mountain, Southern British Columbia

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Ratcliffe, Marilyn J., and Roy Turkington. 1989. Comparative phenology of some alpine vascular plant species on Lakeview Mountain, southern British Columbia. Canadian Field–Naturalist 103(3): 348–352.

Phenological data were recorded weekly for 45 vascular plant species growing in a range of habitat types and at different aspects on Lakeview Mountain in southern British Columbia. Most species flowered 15 to 40 days after snow release. A number of species have delayed phenology in Bellard's Kobresia (*Kobresia myosuroides*) communities and in sites dominated by the sedges *Carex scirpoidea* and *C. capitata*. Aspect has some influence on phenology, with a number of species flowering earlier in south-facing communities, but others such as *Carex capitata* show little phenological variation due to aspect.

Key Words: Phenology, alpine, Lakeview Mountain, British Columbia.

The phenology of vascular plants in alpine zones of North America has received much attention extending from the early part of this century (e.g. Cooper 1908) to the present (Holway and Ward 1963, 1965; Bell 1974; Komarkova 1979). The alpine zones of Canada have been relatively understudied, especially in the southern parts of British Columbia (Douglas and Bliss 1977; Ratcliffe 1983; Ratcliffe and Turkington 1987). Typically, it is argued that aspect, degree of snow accumulation and time of snow melt are largely responsible for variations in alpine plant phenology (Bliss 1956; Holway and Ward 1963, 1965; Mark 1970), and other factors have been given less attention. In this study conducted on Lakeview Mountain in southern British Columbia, we consider the effects of vegetation type on the phenology of species by comparing the phenological progression of a number of species when growing at the same aspect, under similar snow accumulation and snow melt conditions, but living in communities dominated by different species.

Study Area

The study area is located in the alpine zone of Lakeview Mountain in Cathedral Provincial Park, in the southern interior of British Columbia at approximately 49°03′N, 120°09′W. The area ranges from 2402-2500 m and has a mosaic of dry sedge communities, with the dominant species being Bellard's Kobresia, *Kobresia myosuroides* (Vill.) Fiori, and the sedges *Carex scirpoidea* Michx., and *C. capitata* L.

Six sites (labelled A-F) were subjectively chosen to include the most common dominant species present and growing at a range of aspects. Plant community variation within some of these sites permitted subdivision within sites (labelled 1, 2 or 3 as appropriate), providing a total of 11 sites for phenological observation (Table 1). This subdividing within sites permits comparison of species living with different dominants but at the same aspect. In addition, comparisons could be made between species living with the same dominants at different aspects. A detailed description of site selection, subdivision, and plant communities is given in Ratcliffe (1983) and Ratcliffe and Turkington (1987).

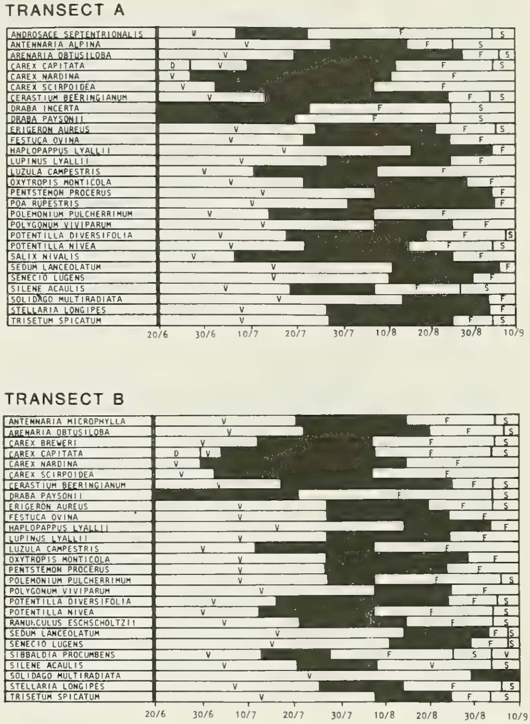
Physical and chemical soil properties were determined within the 11 sites (Table 5 *in* Ratcliffe and Turkington 1987). All profiles are strongly acidic (pH 4.8-5.6) and all soils are coarse-textured, ranging from sandy loam to sand. The A-horizon soils range from 10 cm to 17 cm deep (sites B and C2,F1, respectively). Ratcliffe and Turkington (1987) showed that there were no significant differences between sites in percentage organic matter, total N, available P, exchangeable K, Mg and Ca, and total cation exchange capacity — exceptions were relatively high values for Ca, Mg and total cation exchange capacity in sites D1 and D2. Air and soil temperature profiles for the 1980 growing season showed the same general patterns for all 11 sites (Ratcliffe and Turkington 1987).

Methods

Phenological data were recorded during the 1980 growing season for all the vascular plant species present at each of the sites. A 2 m x 2 m plot was established in each of the 11 sites in June 1980. Typically, this area is snow-free by mid- to late June. After all sites were completely snowfree (18 June 1980), the times of vegetative growth, flowering, fruiting, seed dispersal, and dormancy stages were recorded at weekly intervals until 10 September 1980. At this point, all species were in late fruiting, seed dispersal, or dormant stages.

TABLE 1. Aspect and dominant species for each of the eleven sites used for phenological observation.

Site	Aspect	Dominant
A	N58° W	*Carex capitata* and *Carex scirpoidea*
B	S80° W	*Carex capitata* and *Carex scirpoidea*
C1	N29° E	*Salix nivalis, Carex capitata,* and *C. scirpoidea*
C2	N29° E	*Carex capitata* and *Carex scirpoidea*
D1	S02° E	*Kobresia myosuroides*
D2	S02° E	*Kobresia myosuroides* and *Carex scirpoidea*
D3	S02° E	*Carex scirpoidea*
E1	N16° W	*Kobresia myosuroides*
E2	N16° W	*Carex scirpoidea*
F1	S56° E	*Kobresia myosuroides* (some *Carex scirpoidea*)
F2	S56° E	*Carex capitata* and *Carex scirpoidea*


TRANSECT A

TRANSECT B

FIGURE 1. Phenology of vascular species within trasects A and B from 20 June to 10 September 1980. Solid bars indicate the flowering period, and open bars containing D, V, F, and S indicate dormant, vegetative, fruiting, and seed dispersal stages, respectively. Snow release in all sites took place between 16 and 18 June 1980.

Stages were recorded when at least 50% of a species population (estimated visually) had reached that point. Voucher specimens of all species have been deposited at the University of British Columbia herbarium (UBC).

Results

Data corresponding to the 11 sites described above are presented. Phenology was recorded weekly, so differences of less than 10 days in these figures will not be discussed. Snow release for all sites took place between 16 and 18 June 1980, and all except the Capitate Sedge, *Carex capitata*, had assumed at least vegetative growth at this time (Figures 1-5). Most species flowered 15 to 40 days after snow release. The method of site selection allows us first to evaluate the influence of vegetation type on a species by comparing its phenology when it is growing with different dominant species but at the same aspect. For example, 16 different species occur in both sites E1 and E2; both sites are at the same aspect (N 16° W), but site E1 is dominated by *Kobresia myosuroides* and E2 by *Carex scirpoidea*. Secondly, we can evaluate the influence of aspect on a species by comparing its phenology when it is growing at different aspects but with the same dominant species. For example, 23 different species occur in both sites A and B; both sites are co-dominated by *Carex capitata* and *Carex scirpoidea* but are at different aspects. We wil consider each in turn.

I. The influence of vegetation type on phenology — at constant aspect

Site C (N29° E):

The phenology of vascular species in C1 and C2 is essentially the same, with only two species differing by 10 days or more. Alpine Bluegrass, *Poa alpina* L., flowers 16 days earlier and Spikenard's Sedge, *Carex nardina* Fries, flowers 10 days earlier in C1 than in C2. Flowering periods for these two species terminate at the same time in both sites.

Site D (S02° E):

Three species have major phenological differences within this site. Arctic Sandwort, *Arenaria obtusiloba* (Rydb.) Fern. and Slender Crazyweed, *Oxytropis monticola* Gray ssp. *monticola*, flower an average of 15 days earlier in D3. *Kobresia myosuroides* flowers 14 days longer in D2 than in D1, with fruiting beginning 10 days later as well.

Site E (N16° W):

The majority of species within this site have similar phenological timing. A few species, however, tend to flower earlier in E2 than in E1. Black-tipped Groundsel, *Senecio lugens* Rich., Lyall's Goldenweed, *Haplopappus lyallii* Gray, and *Carex scirpoidea* flower 10 days earlier, although the duration of flowering is the same in

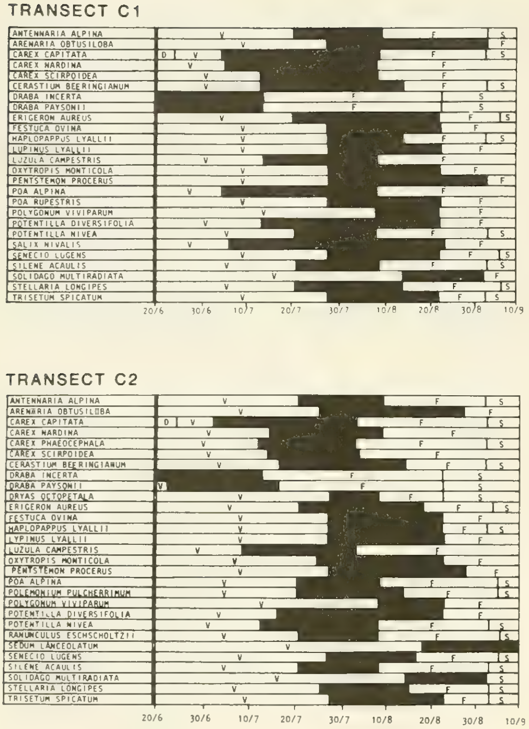


FIGURE 2. Phenology of vascular species within transects C1 and C2 from 20 June to 10 September 1980. See caption of Figure 1 for details.

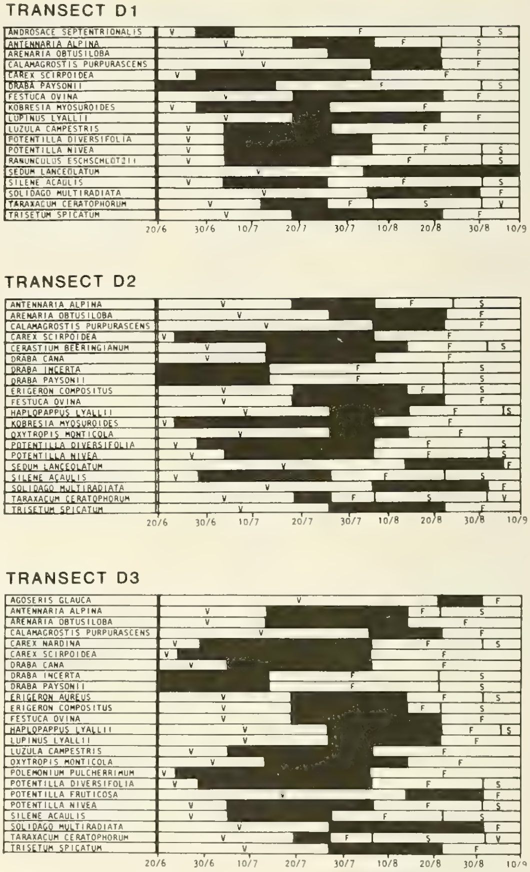


FIGURE 3. Phenology of vascular species within transects D1, D2, and D3 from 20 June to 10 September 1980. See caption of Figure 1 for details.

both sites. Downy Oat-grass, *Trisetum spicatum* (L.) Richter, flowers 16 days earlier and Alpine Chickweed, *Cerastium beeringianium* Cham. and Schlecht, 20 days earlier in E2.

Site F (S56° E):

Many species have similar phenological timing within this site, although several species flower later in F1 than in F2. *Carex nardina, Carex scirpoidea, Cerastium beeringianum*, and Varried Cinquefoil, *Potentilla diversifolia* Lehm., flower 10 to 16 days later in F1.

II. The influence of aspect on phenology — vegetation type constant

Carex capitata/Carex scirpoidea sites (A, B, C2, F2):

Species generally begin periods of flowering and fruiting sooner in site F2 (S56° E) than in sites A (N58° W), B (S80° W), and C2 (N29° E). For example, *Potentilla diversifolia*, Snow Cinquefoil, *Potentilla nivea* L., *Oxytropis monticola*, *Haplopappus lyallii*, Golden Fleabane, *Erigeron aureus* Greene, and Northern Fairy-candelabra, *Androsace septentrionalis* L., flower and/or fruit 10 to 16 days earlier in F2 than in others. A few species flower 12 to 18 days later in C2 than in the remaining sites (e.g. *Cerastium beeringianum*, *Carex scirpoidea* and *Carex nardina*). The duration of flowering is 16 to 20 days longer for Long-stalked Starwort, *Stellaria longipes* Goldie, in this site.

Some exceptions to this general trend are evident. Flowering occurs latest in site B (14 to 20 days) for Alpine Goldenrod, *Solidago multiradiata* Ait, Showy Jacob's Ladder, *Polemonium pulcherrimum* Hook, and *Trisetum spicatum*, and latest in site A (10 to 12 days) for Little-flowered Pentstemon, *Pentstemon procerus* Dougl. Seed dispersal of Payson's Whitlow Grass, *Draba paysonii* Macbr., occurs 10 days earlier in north-facing sites (A and C2) than in south-facing sites (B and F2), while Moss Campion, *Silene acaulis* L., begins seed dispersal 10 days earlier in F2 than in C2.

Carex scirpoidea sites (D3 and E2):

In general, species begin phenological phases earlier in D3 (S02° E) than in E2 (N16° W), or at

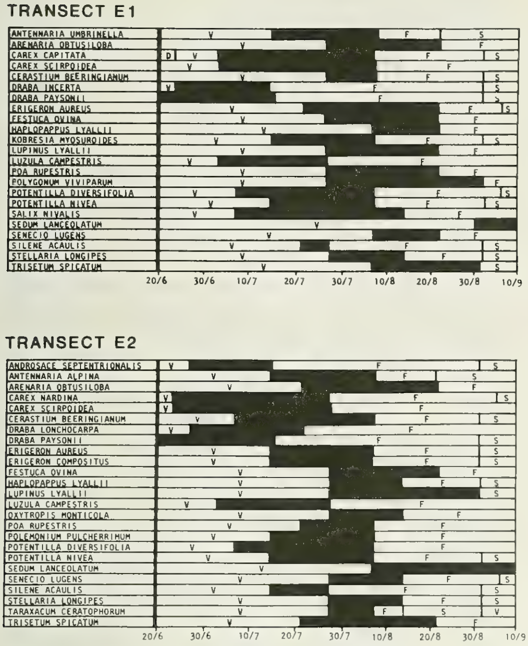


FIGURE 4. Phenology of vascular species within transects E1 and E2 from 20 June to 10 September 1980. See caption of Figure 1 for details.

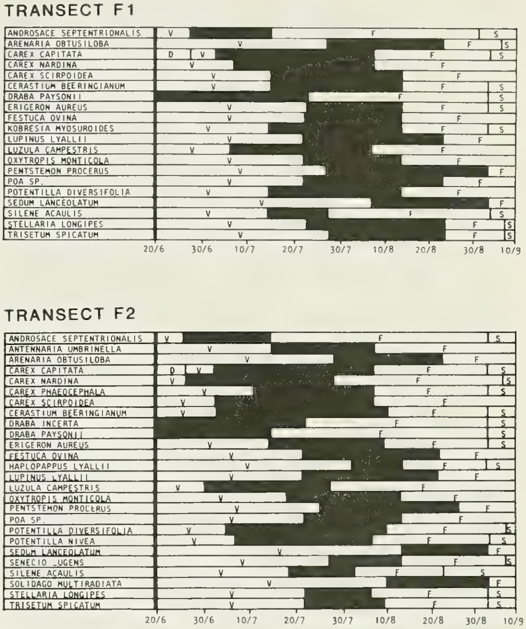


FIGURE 5. Phenology of vascular species within transects F1 and F2 from 20 June to 10 September 1980. See caption of Figure 1 for details.

similar times in both. A number of species flower 10 to 20 days sooner in D3: e.g. Sheep Fescue, *Festuca ovina* L., *Draba paysonii, Polemonium pulcherrium, Oxytropis monticola* and *Silene acaulis.*

Kobresia myosuroides sites (D1, E1, and F1):

Phenological stages tend to be initiated earliest in D1 (S02°E) and latest in E1 (N16°W). For example, *Trisetum spicatum* flowers 10 days sooner in D1 than F1 (S56°E) and 18 days earlier in D1 than in E1. *Silene acaulis, Potentilla diversifolia, Potentilla nivea,* and *Kobresia myosuroides* all flower 10 to 16 days earlier in D1 than in the remaining sites and Common Stonecrop, *Sedum lanceolatum* Torr., flowers 24 days later in E1 than in D1 and F1. *Cerastium beeringianum* flowers 12 days sooner in F1 than in E1. *Carex scirpoidea* is an exception to this trend, flowering 12 to 15 days later in F1 than in E1 and D1.

Discussion

Alpine plants tend to flower and go through other phenological stages very quickly (Bell 1974; Bliss 1971), aided by the almost universal production of overwintering floral primordia (Mark 1970; Billings 1974). Initiation of growth often occurs before the winter snow cover has completely melted, at or near freezing temperatures (Billings and Bliss 1959; Mooney and Billings 1961). In the present study, most species flowered 15 to 40 days after snow release, slightly later than the average reported by Billings (1974) for alpine species in general (10 to 20 days) and by Douglas and Bliss (1977) for western Cascade alpine species (14 to 20 days). The period from floral expansion to seed dispersal (28 to 70 days) is less restricted than the period previously reported for most alpine species (28 to 35 days) (Holway and Ward 1965) and also for western Cascade alpine species (18 to 44 days) (Douglas and Bliss 1977).

The relatively early snowmelt and subsequently longer growing season of the eastern Cascade alpine, compared to the western Cascades and other alpine areas, may have some influence on these differences. The degree of snow accumulation and time of melt is largely responsible for reported variations in alpine phenology (Bliss 1956; Holway and Ward 1963, 1965; Mark 1970). In this study, however, we argue that the identity of the dominant species present and, to a lesser degree, aspect are responsible for variations in phenology, because all sites were uniformly covered with snow, became snowfree at approximately the same time, and had no recorded significant differences in soil characteristics.

The phenological progression of a species is apparently influenced by the dominant species with which it is growing. For example, a number of species (e.g. *Carex scirpoidea, Carex nardina, Potentilla diversifolia*) have flowering and other phenological stages delayed by 10 to 20 days in vegetation dominated by *Kobresia myosuroides*, compared to *Carex scirpoidea*, or *Carex capitata* communities at the same aspect. A similar phenological delay was observed for some species (e.g. *Cerastium beeringianum, Potentilla diversifolia, Carex nardina* and *Carex scirpoidea*) within communities co-dominated by *Carex scirpoidea* and *Carex capitata*, when compared to "pure" *Carex scirpoidea* communities. Dominant species may modify microsite conditions in many ways and thus influence the phenology of their neighbours.

Without properly controlled field experiments it is not possible to identify specific mechanisms but various speculations are possible. For example, the willow *Salix nivalis* has leaves oriented close to the ground and an open growth form, with "gaps" of bare soil between leaves. This produces a microenvironment with relatively high humidity and moisture levels, warmer temperatures, and protection from the wind. Also, although not statistically significant ($p > 0.05$), soil temperature at 2 cm depth under *Kobresia myosuroides* communities are 3-4°C cooler than soils under *Carex scirpoidea* and *C. capitata* communities.

While aspect appears to have little influence on the distribution of species and communities, it does in some cases influence the timing of phenological stages. A number of species tend to flower earlier in south-facing communities. These species often differ between communities, although *Potentilla diversifolia* and *Silene acaulis* consistently flower and/or fruit 4 to 12 days earlier at the most southerly aspect sampled for a particular community. Other species such as *Carex capitata* show little phenological variation due to aspect.

The major aim of this study was to record phenological variation in species growing at different aspects and with different neighbours because it is not easy to clearly establish vegetation-environment causal relationships in a short-term study. In this, and in the concurrent study (Ratcliffe and Turkington 1987), we were unable to detect any obvious relationships, so instead focussed on the influence of biotic factors on local vegetation patterns.

Acknowledgments

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Small Mammals of the Boundary Waters Canoe Area, with a Second Minnesota Record for the Heather Vole, *Phenacomys intermedius*

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Small mammals were surveyed using mouse traps on island and mainland areas on the Minnesota and Ontario sides of Lake Saganaga, about 95 km north of Grand Marais, Minnesota. The 7000 trap-night survey yielded about 1500 specimens representing 16 species. Included are 2 specimens of *Phenacomys intermedius*, 1 *Sorex hoyi*, and 70 *Microtus chrotorrhinus*. *Microtus chrotorrhinus* and *Synaptomys cooperi* populations appeared to increase dramatically over the 20 years of the study.

Key Words: *Phenacomys intermedius*, small mammals, Minnesota, Ontario, distribution.

Northeastern Minnesota is at or near the periphery of the known ranges of several small mammals, including the Rock Vole, *Microtus chrotorrhinus,* the Woodland Jumping Mouse, *Napaeozapus insignis*, and the Heather Vole, *Phenacomys intermedius*. Since the region is remote from universities and biological field stations, sampling there has been limited. I was initially intrigued with the possibility of taking additional Minnesota specimens of *Microtus chrotorrhinus* when I began sporadic trapping in the area during the early 1960's. Efforts intensified in 1981, when our cat provided my first specimen of *M. chrotorrhinus*.

Study Area and Methods

Lake Saganaga, one of the larger lakes straddling the Minnesota-Ontario border, is located at the end of the Gunflint trail, about 95 km north of Grand Marais, Minnesota. Terrestrial habitats of boreal forest are typical for the region. White Pine (*Pinus strobus*), Red Pine (*P. resinosa*), Jack Pine (*P. banksiana*), Balsam Fir (*Abies balsamea*), Paper Birch (*Betula papyrifera*), and Quaking Aspen (*Populus tremuloides*) dominate well-drained areas, where soils are thin and exposed granite boulders are prevalent. Woody understory plants in these areas include Mountain Maple (*Acer spicatum*), Blueberry (*Vaccinium* spp.), Leather Leaf (*Chamaedaphne calyculata*), American Yew (*Taxus canadensis*), and Prostrate Juniper (*Juniperus communis*). White Cedar (*Thuja occidentalis*), Sand Cherry (*Prunus pumila*), Tag Alder (*Alnus rugosa*), and "Diamond" Willow (*Salix* sp.) are common near the lakeshore. Poorly drained areas contain Black Spruce (*Picea mariana*) with occasional stands of Black Ash (*Fraxinus nigra*) and Balsam Fir. The understory in poorly drained areas is similar to that described above but lacks Prostrate Juniper and Yew. Marshes and wet meadows, many formed by beaver activity, contain grasses and sedges, and may have patches of Tag Alder, Leather Leaf, Red Raspberry (*Rubus strigosus*), Sweetgale (*Myrica gale*), and Blueberry.

Small mammal sampling included all habitats, but effort was concentrated in poorly-drained areas where species diversity appeared to be highest and non-target taxa such as the Southern Red-backed Vole, *Clethrionomys gapperi*, and the Woodland Deer Mouse, *Peromyscus maniculatus gracilis*, were least likely to be common. Early efforts (1962-1980) were sporadic and often consisted of fewer than 100 trap nights per summer, whereas 1981-1987 effort averaged nearly 1000 trap nights per summer. During 1981-1984, 20-50 traps were set per night, and typically relocated daily. The latter three summers, 50 traps were worked in the same area for 5 days (250 trap nights).

Peanut butter was used for bait throughout the study. Individual traps were set in likely spots (in or near burrows, under boulders or logs) at intervals of 1-20 m, and a broken green branch was placed near the trap with its butt end pointing toward the next trap. Traps were individually marked as odd- or even-numbered to avoid missing a trap, and each tenth trap was marked with a double branch. Daily capture efficiency occasionally exceeded 50%. Failure to locate traps was never a problem. Trap attrition, both from movement of trapped animals and pilfering (presumably by mustelids and raptors) was about 1-2% per night until traps were secured to a limb, root, or shrub with a short string. No traps were lost in 1000 trap nights after strings were attached.

Study skins and skeletons have been deposited primarily at the James Ford Bell Museum of Natural History, University of Minnesota, Minneapolis (MMNH). Additional repositories for study skins were Tulane University and the University of Tennessee. Skeletal material not accompanied by study skins was deposited in the University of Tennessee Zooarchaeology collection. Trapping localities are indicated on Figure 1, and several areas frequently sampled during the study are described in some detail. An annotated list of species collected is presented, with 1981-1987 data summarized in Table 1.

Areas Frequently Sampled

Trapping effort was concentrated in several areas, grouped together by habitat, and described below. Trapping area localities are indicated in Figure 1, and captures by habitat are tabulated in Table 2.

Areas 1 and 2, Minnesota Mainland Wet Meadows: These grass and sedge areas typically have standing water except in late summer. Lack of trees is apparently caused by flooding due to beaver dams, with standing and fallen trunks of dead trees still conspicuous. Some woody plants (Red Raspberry, Tag Alder, Black Spruce, Balsam Fir) are beginning to reinvade, especially along edges.

Areas 3-8, Minnesota Mainland Wet Woodlands: All of these are on the mainland penninsula east of Smith and Schlei Island, and are typified by poorly drained woodlands with occasional standing water, a wide variety of trees with Black Spruce and Balsam Fir most common, a complete canopy with no grasses, and a virtual absence of exposed boulders. Mosses, ferns, Horsetail (*Equisetum*), and Ground Pine (*Lycopodium*) are prevalent, but the substrate lacks the spongy feel of a sphagnum bog.

Area 9, Wadurski Marsh: This sedge and grass area on Red Pine Island is drained by a meandering stream and is contiguous with a shallow bay of Lake Saganaga. Scattered patches of woody plants (Sweetgale, Tag Alder) occur, but there are no trees or indication of previous forestation. Standing water is common except along the marsh edge. A few beaver channels form small tributaries to the main drainage stream.

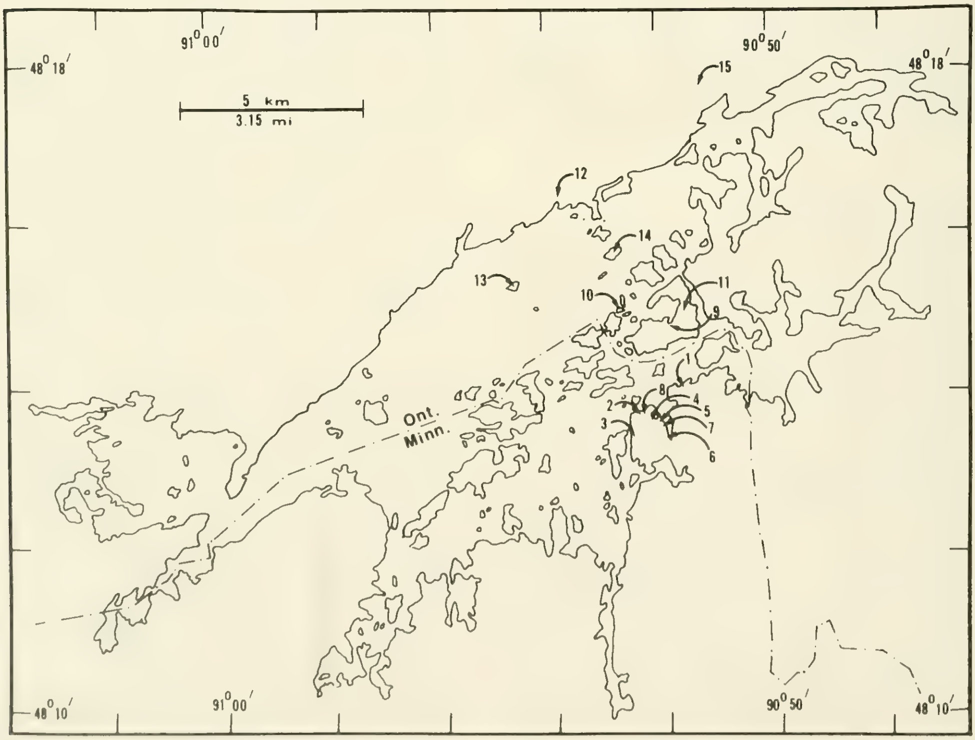

FIGURE 1. Map of the Lake Saganaga, Ontario, and Cook County, Minnesota, area. Numbered localities 1-8 (Minnesota mainland), 9 and 11 (Red Pine Island), and 10 (New Lewis Island) described in text. Locality 12 = north shore, 13 = Seagull Island, 14 = Eagle Nest Island, 15 = portage to Lake Saganagons.

TABLE 1. Summary of Small Mammal Collections, 1981-1987, Lake Saganaga, Ontario and Cook County, Minnesota.

	1981	1982	1983	1984	1985	1986	1987	Total
Clethrionomys gapperi	81	5	19	2	331	190	195	823
Peromyscus maniculatus	59	0	8	0	35	2	5	109
Sorex cinereus	12	0	4	0	7	21	27	71
Microtus chrotorrhinus	1	0	0	0	1	11	57	70
Microtus pennsylvanicus	0	0	1	3	9	18	20	51
Synaptomys cooperi	0	1	0	0	9	6	16	32
Blarina brevicauda	8	6	2	0	2	8	2	28
Zapus hudsonius	0	2	5	0	9	3	2	21
Sorex arcticus	0	0	2	0	0	5	1	8
Sorex palustris	4	0	0	0	2	1	1	8
Tamias minimus	0	0	3	0	1	0	2	6
Condylura cristata	1	0	0	0	0	2	0	3
Phenacomys intermedius	0	0	0	0	0	1	1	2
Sorex hoyi	1	0	0	0	0	0	0	1
Captures	167	14	44	5	406	268	329	1233
Trap Nights	993	298	688	98	1669	1217	1756	6719
Captures per 100 Trap Nights	16.8	4.7	6.4	5.1	24.3	22.0	18.7	18.4

Area 10, New Lewis Island: Consists of approximately 3 acres, mostly of well drained upland White and Red Pine forest, but there also is a small area dominated by mature Black Spruce. Boulder piles and bedrock are exposed or shallowly buried by thin soils over most of the island. The understory has abundant Blueberry and Balsam Fir, and patches of American Yew, Mountain Maple, Birch, Prostrate Juniper, Leather Leaf, and Tag Alder. Although remote, adjacent small islands form "stepping stones" to the mainland with intervening water barriers about 100-200 m wide.

Area 11, Cranberry bog: A nearly level, poorly drained sphagnum bog of about 3 acres circled by steep ridges. The water table is consistently near surface, but standing water is present only after periods of heavy rainfall. Trees (Black Spruce, Balsam Fir; a few Tamarack, *Larix laricina*) form a sparse canopy. Understory consists of Blueberry, Leather Leaf, and scattered sapling Birch and Mountain Maple. Bog Cranberry (*Vaccinium* sp.)

TABLE 2. Tabulation of Small Mammal Captures by Habitat Type. Area 1-2 (Minnesota mainland wet meadows), area 3-8 (Minnesota mainland wet woodlands), area 9 (Wadurski marsh), area 10 (New Lewis Island), and area 11 (Cranberry bog) are characterized in Materials and Methods.

	Areas 1-2	Areas 3-8	Area 9	Area 10	Area 11
Condylura cristata	1	0	0	0	0
Blarina brevicauda	3	0	1	1	1
Sorex arcticus	7	1	0	0	0
Sorex cinereus	6	20	17	7	3
Sorex palustris	0	1	7	0	0
Tamias minimus	2	2	0	0	0
Peromyscus maniculatus	16	5	5	0	0
Clethrionomys gapperi	36	197	89	33	115
Microtus chrotorrhinus	0	55	0	2	10
Microtus pennsylvanicus	10	0	28	0	7
Phenacomys intermedius	0	1	0	0	1
Synaptomys cooperi	0	12	7	0	11
Zapus hudsonius	2	0	11	0	0
Captures	83	294	165	43	149
Trap Nights	633	1321	1036	764	568
Captures per 100 Trap Nights	13.1	22.3	15.9	5.6	26.2

is present but not abundant. Exposed boulders are lacking.

Results: Annotated Species List

Sorex arcticus (Arctic Shrew): Reasonably abundant along the edges of two wet meadows (7 specimens in 633 trap nights) on the Minnesota mainland (areas 1 and 2, Figure 1). The only additional specimen was taken in an upland habitat (area 7) near these areas. No specimens were taken in 1036 trap nights in a similar habitat (Wadurski Marsh, area 9) on Red Pine Island, where *S. palustris* was prevalent.

Sorex cinereus (Masked Shrew): Abundant in all habitats sampled. Comparison of captures by domestic cats on New Lewis Island (area 10) with trapping results indicates that snap traps baited with peanut butter are inefficient for sampling this species, and probably all shrews.

Sorex hoyi (Pygmy Shrew): The single specimen (MMNH 14820) was taken in a Black Spruce and Black Ash swamp on the north shore (area 12). Teeth of an additional 50 or so small *Sorex* caught by domestic cats on New Lewis Island were checked, but none was *S. hoyi.* Timm (1975) and Hazzard (1982) include no records for Cook County, Minnesota, but Nagorsen and Peterson (1981) reported specimens from adjacent Quetico Provincial Park.

Sorex palustris (Water Shrew): Reasonably abundant in Wadurski Marsh (area 9) where traps set on the edge of beaver channels were particularly effective. Several additional specimens were taken in boulder piles along the lake shore prior to 1981.

Blarina brevicauda (Northern Short-tailed Shrew): Present in all habitats sampled. Color variation was appreciable, with specimens ranging from the typical dark gray to silver, beige, and coal black.

Condylura cristata (Star-nosed Mole): Although probably common in moist habitats throughout the area, Star-nosed Moles, because of their large size and annelid-arthropod diet, are probably poorly sampled by methods used in this study. Of the three specimens taken, two were from a wet meadow (area 2) and one was from a Black Spruce swamp (area 12).

Tamias minimus (Least Chipmunk): All six specimens were from mainland areas. It is apparently a reluctant swimmer, as I have not seen this often conspicuous animal on islands in Lake Saganaga. *Tamias striatus*, the Eastern Chipmunk, is common around dwellings near the public landing at the south end of the lake, but was not seen or taken in the study area.

Glaucomys sabrinus (Northern Flying Squirrel) and *Tamiasciurus hudsonicus* (Red Squirrel): Both of these squirrels are common in the area, but are too large to be taken with regularity in mouse traps. Single specimens of each were taken in the early years of the study.

Peromyscus maniculatus (Woodland Deer Mouse): Common in dry brush island and mainland habitats, but rarely taken in poorly drained areas and apparently absent from some smaller islands. They were particularly abundant on Seagull (area 13) and Eagle Nest (area 14) islands. All specimens were typical of *P. m. gracilis*.

Clethrionomys gapperi (Southern Red-back Vole): Dominant in virtually all wooded habitats, and representing over two-thirds of all specimens taken, red-backs were not taken in grass and sedge areas except along the forest edge. Two color variants, both from area 11, are noteworthy. A 1986 specimen (MMNH 14845) had pure white covering the entire tail, front and hind limbs, and on the head from the upper snout back on each side to the base of the ears and extending dorsad nearly to the lower margin of the eyes, with an extension from the snout along the median margin of the left eye nearly to its posterior border. A white saddle continuous with the white belly and about 1 cm wide extended across the nape. One captured in 1987 (MMNH 15032) was beige in general color, but had a normal pattern.

Microtus chrotorrhinus (Rock Vole): Previously poorly known from the area (Timm 1975; Hazzard 1982), this vole was abundant in samples taken in 1986 and 1987 from areas 3-8 and 11, where it occasionally replaced *C. gapperi* as the most frequently collected species. A few additional specimens were taken in a variety of drier upland habitats, but none was taken from sedge or grass areas or along their edges.

Microtus pennsylvanicus (Meadow Vole): Generally common in wet meadows and sedge marshes, uncommon but typically present in wooded areas.

Phenacomys intermedius (Heather Vole): The only previous Minnesota record (Handley 1954; Hazzard 1982) is a 1940 specimen (U.S. National Museum 27491) from somewhere near Ely, in St. Louis or Lake county, collected by Shaler Aldous. According to Timm (1975), Aldous' field notes indicate that the specimen was collected at Lake States Experimental Forest in Lake County, but the label accompanying the specimen indicates Ely, St. Louis County, as the locality. Single specimens were taken from area 11 on the Ontario side in 1986 (MMNH 14849), and area 7 on the Minnesota side in 1987 (MMNH 15048). Heather Voles appear to be considerably more common in nearby areas of Quetico Provincial Park, Ontario, where 16 or 17 specimens (exact number not specified) were collected in 8783 trap nights during a 1977-1979 survey (Nagorsen and Peterson 1981; Nagorsen 1987). Heather Voles were collected at 4 localities within 50 km of the 2 *P. intermedius* sites at Lake Saganaga, as follows: Emerald Lake (48°07′N, 91°14′ W), 35 km WNW of Lake Saganaga sites; Reid Lake (48° 18′N, 91° 21′W), 45 km W; Kawa Bay (48° 24′ N, 91° 08′ W), 44 km NW; and Cache Lake (48° 33′ N, 91° 03′W), 41 km NNW.

Synaptomys cooperi (Southern Bog Lemming): Although increased catches of Rock Voles (2 prior to 1986, 11 in 1986, 57 in 1987) may reflect differences in trapping sites rather than increased abundance, it seems likely that *S. cooperi* populations were much higher during 1985-1987 than in earlier years. Prior to 1985, with an estimated effort of 2400 trap nights, only one *S. cooperi* was collected, from a wet meadow on the portage between lakes Saganaga and Saganagons (area 15). During 1985-1987, 31 specimens were taken in a variety of habitats in 4642 trap nights, several were provided by cats on New Lewis Island, and one dead specimen was found floating in the lake near Eagle Nest Island (area 14). *Synaptomys* were taken in direct association with both species of *Microtus* in both moist areas and upland forests, but were more common in the moist areas.

Zapus hudsonius (Meadow Jumping Mouse): Taken in all habitats sampled, but most abundant in grassy areas. Jumping mice apparently are not very vulnerable to the trapping methods used. On several occasions I saw them hopping about in the immediate vicinity of baited, unsprung traps but failed to capture specimens at such times. One was caught by a cat on New Lewis Island, but I did not catch any there in 764 trap nights. The Woodland Jumping Mouse, *Napaeozapus insignis*, may occur in the area, as it was represented in surveys of nearby areas (Timm 1975; Nagorsen and Peterson 1981).

Discussion

The diverse small mammal fauna of the boreal forest is notoriously difficult to sample adequately. In spite of over 7000 trap nights of effort covering all available habitats, I am not confident of the absence of *Napaeozapus* and *Synaptomys borealis* from the Lake Saganaga area, or of the rarity of *Phenacomys* and *Sorex hoyi*. The remarkable success of our cats (one or two per summer) on New Lewis Island is humbling. While I typically collected only about 5 specimens per 100 trap nights there, they were routinely bringing 2 or 3 per day to the cabin, and probably eating or leaving in the woods many more. In spite of spending about 2 months per summer for the past 13 years on this 3-acre island, and with 764 trap nights of effort, I have not seen or collected *Zapus, Synaptomys, Microtus pennsylvanicus,* or *Mustela erminea*, all of which have been provided by the cats.

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Elmer Birney and Gerda Nordquist, University of Minnesota and MMNH, provided a repository for specimens, identified the single *Sorex hoyi* I had overlooked, and confirmed other identifications. They, and Gary McCracken and John Gittleman, University of Tennessee, made valuable comments on an earlier draft of this paper. My wife, Liz, also provided editorial assistance, and was remarkably tolerant of my frequent use of our cabin for small mammal storage and study skin preparation. Suggestions by two anonymous reviewers resulted in improved organization of the paper.

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The Lemming Community on the Lichen-Heath Tundra at Churchill, Manitoba

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Scott, Peter A., and Roger I. C. Hansell. 1989. The lemming community on the lichen-heath tundra at Churchill, Manitoba. Canadian Field–Naturalist 103(3): 358–362.

During 1984, a community of small mammals located within an "island" of lichen-heath tundra in the forest-tundra near Churchill, Manitoba was studied. *Dicrostonyx richardsoni* shares the area with two eurytopic species; *Sorex cinereus, Microtus pennsylvanicus* and three Boreal species; *Phenacomys intermedius, Clethrionomys gapperi*, and *Synaptomys borealis*. Of the three most abundant species, *D. richardsoni* was trapped in the upland sites along with *P. intermedius*, and *M. pennsylvanicus* was trapped in the lowland sites. In comparison to other populations of the species, the Churchill population of *D. richardsoni* is residing in a community with more southern species of small mammals. The high density of the burrows, and the slow rates for peat accumulation shows that most of the burrows date to a previous period. *D. richardsoni* may have been more widespread during colder climatic periods such as the Little Ice Age. *P. intermedius, C. gapperi, and S. borealis* are not characteristically found on tundra and, therefore, may be recent invaders encouraged by the recent favourable climate.

Key Words: Small mammals, *Dicrostonyx richardsoni*, Churchill, Manitoba, lichen-heath tundra, climate change.

Distribution studies of *Dicrostonyx richardsoni* near the town of Churchill, Manitoba (58° 45′ N, 94° 05′ W) have mainly focused on beach communities. The first formal description of the Churchill population of *D. richardsoni* by Merriam (1900) resulted from collections by E. A. Preble in 1900 (Preble 1902). [This population has also been referred to as *D. groenlandicus* or *D. torquatus* in the literature.] Preble (1902) concluded that *D. richardsoni* lived mainly on "gravelly ridges" and "old raised sea beaches". Shelford and Twomey (1941) studied small mammals near Churchill from 1928-1939 and described *D. richardsoni* distributions in relation to the surrounding flora with an emphasis on beach ridge communities (*see also* Smith and Foster 1957). Brooks (1970) trapped *D. richardsoni* at Churchill during 1967-1969 and reported on burrow structure, dietary preference, and radio-tracking studies within a beach community, Wrigley (1974) discussed small mammal distributions in northern Manitoba in general.

During 1980, *D. richardsoni* was more abundant within the deep peat of the lichen-heath tundra community than within beach communities at Churchill (Scott 1988). While Scott (1988) concurs with the dietary preference of *D. richardsoni* for *Salix* spp. and *Dryas integrifolia* reported by Brooks (1970), he argued that their distribution relates more closely to rock cover than to food abundance.

For three years following the 1980 study (Scott 1988) and again in 1985-1987, small mammal numbers were too low to derive useful information about their distribution. This report details a study undertaken during 1984. The first objective was to describe the small mammal community at Churchill on lichen-heath tundra, where *D. richardsoni* was most abundant and found most consistently throughout 1980-1987. The second objective was to relate the community structure to changing environmental conditions, primarily using burrow analysis. Burrows are a useful remnant left by small mammals which, in this case, were dug in well-preserved peat that has been accumulating since the land emerged.

Methods

A 14.75 ha area of lichen-heath tundra was selected on the Churchill Quartzite rock outcropping (Sanford et al. 1967) on land owned by Boreal Projects Ltd. (Figure 1). The south of the site is marked by a cliff that leads to wet beach meadows and the north by a cliff leading to the Hudson Bay shore. The elevation ranges from above 22 m to less than 15 m above mean tide. From the uplift curve developed by Craig (1968) the land would have begun emerging from the Tyrell Sea approximately 2000 years ago and had mostly emerged within 300 years. The site appears to have been free from physical disturbances such as fire.

The site was surveyed relative to I.G.Y. #2 bench mark and a grid was established with 50 m intersect points (Figure 2). On top of the rock are basins of relatively deep fibric peat (up to 75 cm in depth) ranging to 5 m in diameter. Occasionally there are larger meadows in areas of faulting and small ponds exist in some basins. In spring, the conductive properties of the Quartzite accelerates ground thaw from all sides of these peat basins and

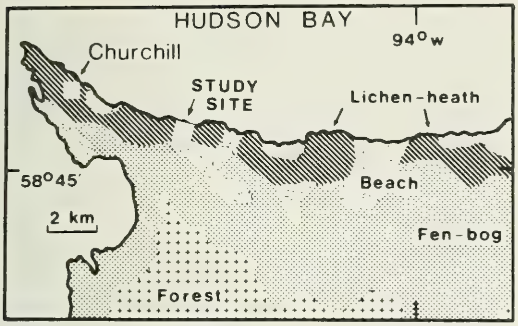

FIGURE 1. The Churchill area showing the location of the lichen-heath tundra study site (white block) in relation to open forest as well as the fen-bog and beach meadows of the forest-tundra (*after* Scott 1988).

by August, the entire area has thawed some 15 m into the rock below (Brown 1978).

Complex plant communities occur in relation to microtopography and drainage. These communities form patches ranging from 10 cm to several metres in size. In order to simplify the description, the plant community within a 5 m radius of each capture site was described by the most dominant appearing species.

Small mammal fauna was sampled by snap-trapping during a 16-day period in August 1984. Groups of ten traps were baited with rolled oats and peanut butter and placed around burrows in the centre of either 14 or 15 of the 50 × 50 m quadrats and this process was repeated until all 59 quadrats had been trapped, a total of 2360 trap-days. The specimens were identified and prepared as skins and skulls and deposited in the collection of the department of Mammalogy, Royal Ontario Museum (catalogue numbers 94286-94333).

Burrows were counted in five randomly selected 50 × 50 m plots and burrow diameter and length was measured to compare with measurements made by Brooks (1970) on sand-based sites. To assess the work involved in burrowing, a 74 cm column of peat was removed and the peat density was calculated for groups of three samples taken at 3 cm intervals throughout the column. Several more peat columns were taken and the composition was examined.

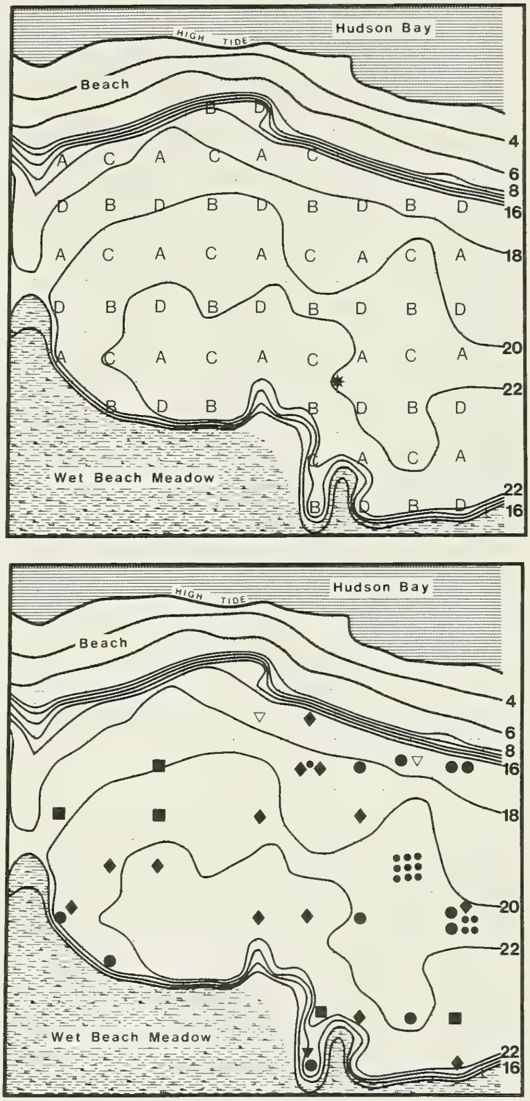

FIGURE 2. The study site on the lichen-heath tundra with 2 m elevation contours and the 50 × 50 m trapping quadrats superimposed (dotted lines). The top map shows the 1984 trapping pattern during 7-23 August in four day periods (A, B, C, D). The lower map records the location of each animal caught; *Microtus pennsylvanicus* (solid circles; smaller circles represent animals weighing 8-14 gms), *Phenacomys intermedius*, (squares); *Clethrionomys gapperi* (solid triangle); *Synaptomys borealis* (open triangles); and *Dicrostonyx richardsoni* (diamonds). The location of I.G.Y. #2 survey bench mark (75 ft) is marked by an asterisk (top map).

Results

A total of 15 community types was described by aspect dominance at successful trap locations (Table 1). Lichens dominate most upland areas and mosses dominate in all other areas. The upland communities were composed of mainly *Cetraria nivalis, Bryoria nitidula,* and *Bryocaulon divergens* with *Empetrum nigrum, Arctostaphylos rubra,* and *Rubus chamaemorus.* Lower communities includes *Vaccinium uliginosum, Ledum*

TABLE 1. Fifteen community types are described by aspect dominance and ranked from the dryest, most exposed, to the wettest, least exposed areas. The community types are compared with the frequency of capture for each small mammal species.

Species	D.t.	P.i	S.c.	M.p.	C.g.	S.b.
Lic	1	-	-	-	-	-
Lic-Emp	2	1	1	-	-	-
Emp-Led-Rub	1	2	1	-	-	-
Emp-Led-Lic	-	1	1	-	-	-
Emp-Led	2	1	-	-	-	-
Emp-Arc	2	-	-	-	-	-
Emp-Arc-Mos	1	-	-	-	-	-
Emp-Vac-Mos	-	-	-	1	-	-
Led-Vac-Mos	2	-	-	-	-	-
Led-Mos	-	-	-	1	-	-
Car-Mos	-	-	-	2	-	-
Emp-Mos-Sal	1	-	-	11	-	-
Car-Mos-Sal	1	-	-	7	-	1
Mos-Sal	-	-	-	1	1	-
Sal	-	-	-	1	-	1

D.t. = *Dicrostonyx richardsoni*; P.i. = *Phenacomys intermedius*; S.c. = *Sorex cinereus*; M.p. = *Microtus pennsylvanicus*; C.g. = *Clethrionomys gapperi*; S.b. = *Synaptomys borealis*. Lic = Lichen spp.; Emp = *Empetrum nigrum*; Led = *Ledum* spp.; Rub = *Rubus chamaemorus*; Arc = *Arctostaphylos rubra*; Mos = Moss spp.; Car = *Carex* spp.; Sal = *Salix* spp.

decumbens, Salix planifolia, and moss species. The wetlands were moss covered with *S. reticulata, S. arctophila*, and *Carex vaginata*. Around ponds, *S. planifolia* dominated with *Betula glandulosa*. [Specific numeric descriptions are reported in Scott 1987, 1988.]

Forty-nine animals representing six species were trapped from the 59 quadrats over 16 days. This represents one animal captured per 48 trap-days. Thirty-four (70%) of the animals were captured between the period from sundown until after sunrise and 36 (75%) of the animals were male. Twenty-five (51%) of the animals were *Microtus pennsylvanicus* and 13 were *Dicrostonyx richardsoni* (27%). The remaining animals included five *Phenacomys intermedius*, two *Synaptomys borealis*, one *Clethrionomys gapperi*, and three *Sorex cinereus* (Figure 2). Many of the animals were juvenile and in some quadrats it was evident that most of the members of dispersing litters of *M. pennsylvanicus* were trapped. The following enumeration represents sexually mature animals: nine *D. richardsoni*, seven *M. pennsylvanicus*, four *P. intermedius*, and one each of *S. borealis*, and *C. gapperi*. *M. pennsylvanicus* was trapped in the wet areas dominated by moss and shrub around ponds. *D. richardsoni* was trapped in the most extreme upland lichen-heath as well as in some of the wetter sites. The large variation in capture sites is probably a result of the large ranges characteristically traveled by this species (Brooks 1970). *P. intermedius* inhabited a narrower range of upland communities (Table 1). Too few captures of other species were made to allow for general descriptions.

Three burrow complexes of *Alopex lagopus* were found at the site as well as five burrow complexes used by *Lepus americanus*. The remaining burrows are attributed to *D. richardsoni, C. gapperi, M. pennsylvanicus, S. borealis* and *P. intermedius*, and are separated into two main types. One type of burrow is developed when moss is removed (eaten ?) and the animal then enters under the moss and pushes open a tunnel with little excavating. This is a frequent type of burrow in moss hummocks and in moss mounds at the base of birch (*Betula glandulosa*) and willow (*Salix* spp.) shrubs found around small ponds and under White Spruce (*Picea glauca*) trees. The captures have shown this type of burrow in wet habitat to be the work of *M. pennsylvanicus* and possibly *S. borealis*. The second type of burrow is made by excavating which results in deeper tunnels into the peat and are commonly inhabited by *D. richardsoni* and *P. intermedius*.

The burrow entrances ranged from 5 to 6 cm in diameter and occurred at an average of every 4 m^2. As 22% of the site is covered by rock and 9% is covered by water in ponds (Scott 1988), there are approximately 25 000 burrows located in slightly more than 10 ha of available land.

The peat samples were well preserved and uniform in composition. Organic litter characteristic of the lichen-heath tundra was identified for all depths except for the bottom 3 cm which was composed of sedge material. The peat densites above the sedge material ranged from 0.1850 to 0.2500 gm ml^{-1} with an average of 0.2139 gm ml^{-1}.

Discussion

Comparison of known elevations with declining rates of isostatic rebound (Craig 1968) indicates that most of the Churchill Region was still innundated by the Tyrell Sea 2500 years B. P. (Scott 1987). Since that period, large tracts of barrens developed initially and then, in the last millenia, spruce forests intruded onto the barrens south, west, and northwest, effectively isolating the remaining tundra from the continental tundra. The Churchill region was dominated by arctic conditions during the early part of the Little Ice Age [e.g., 1200 to 1760 A.D.] (Lamb 1982). Arctic conditions were less dominant during 1760 to 1820 although another cool period followed (Scott et al. 1988). From 1921 through the late 1960s there was a period of relative warmth which also occurred throughout the Northern Hemisphere (Jones et al. 1986; Kelly et al. 1982). With the introduction of continuous weather reporting at Churchill during this warm period, the climate summaries available (e.g., Canada 1962) show this area predominately forest-tundra and tundra underlain by continuous permafrost (Brown 1978), as more temperate or "Boreal" in climate. Early small mammal communities on the tundra may have established under cool conditions while later communities, especially during much of this century, have been exposed to a more temperate climate.

The presence of 2500 burrows ha^{-1} is a much greater density than is needed to support the current population of small mammals. On the basis of the 1980 study (Scott 1988), it is reasonable to assume a population density of 15 sexually mature females ha^{-1} for each species. Thus, with an even sex ratio, there could be as many as 180 burrow dwelling animals ha^{-1} or one animal for every 13.9 burrows. If each burrow is 6 cm in diameter and 2 m in length on average (Preble 1902; Brooks 1970), the excavation of an average burrow would require the displacement of at least 5.9 litres of peat. With a peat density of 0.2139 gm ml^{-1} and an average soil moisture of 300% (Scott 1987), a burrow would require slightly more than 19 kg of peat displacement. The average burrowing mammal would have to move 265 kg of peat in a period of approximately 90 days during which the ground is thawed and the total displacement of peat ha^{-1} $season^{-1}$ would be greater than 47.6 tonnes. Furthermore, with an average peat depth of 30 cm (Scott 1987), this annual displacement represents slightly less than 2% of the entire volume of peat. As many of the plants on the surface are clearly older than 50 years, and there are few signs of freshly excavated peat, there is no indication that anything near this quantity of peat is being displaced. Furthermore, at a rate of peat accumulation of 1.5 cm $century^{-1}$, it would take three or four centuries to cover an abandoned burrow that was filled with wind blown litter. So it is evident that many of the current burrows date well into the Little Ice Age.

The use of a burrow by a particular species is not a reliable indicator that it is an original inhabitant, as in several cases more than one species was trapped in the same burrow complex, although usually on different nights. This observation indicates that burrows can be inhabited by different species over time; supported by the fact that *P. intermedius* were caught on upland sites in burrow complexes with diameters much larger than necessary. However, *D. richardsoni* are commonly found in sympatric communities with *Lemmus sibiricus* (Gileva 1983) and *C. rutilis* (Hall and Kelson 1959; Banfield 1976) throughout most of their range. The southern range limit of the latter two species is near the Seal River (Hall and Kelson 1959; Wrigley 1974) at the southern limit of the continental tundra. Today at Churchill, *D. richardsoni* is found on upland sites with, among other species, the more southern *C. gapperi* and with *M. pennsylvanicus*. Whereas an earlier record of *L. sibiricus* has been reported for Churchill (Quay 1955), *M. pennsylvanicus* currently occupies wet meadow habitat similar to that of *L. sibiricus* at other locations (Scott 1988).

It is an unlikely coincidence that *D. richardsoni* resides primarily in "islands" of tundra within the forest-tundra at Churchill. The uniform composition of the peat profiles from the lichen-heath tundra indicates that it was established here more than 1000 years ago and this is evidently more preferred habitat for *D. richardsoni* than for any of the other species. For example, Foster (1961) reported that *Phenacomys intermedius* is rarely found in fully open sites such as the study area. Earlier populations of *D. richardsoni* could be responsible for the development of burrow complexes during the Little Ice Age that are used by other small mammals today. Whereas *M. pennsylvanicus* inhabits the southern regions of tundra, *P. intermedius, C. gapperi*, and *S. borealis* are rarely found on tundra (Hall and Kelson 1959). It may be that the presence of the latter three species represents a later invasion encouraged by a favourable climate change.

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Summer Food Habits of Sympatric Arctic Foxes, *Alopex lagopus*, and Red Foxes, *Vulpes vulpes*, in the Northern Yukon Territory

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Food habits of sympatric Arctic Foxes (*Alopex lagopus*) and Red Foxes (*Vulpes vulpes*) were determined from 31 Arctic Fox scats (from three active natal dens) and 39 Red Fox scats (from two active natal dens) collected in the northern Yukon Territory in summer 1985. Prey consumption was quantified in terms of percentages of fragments and percent frequency occurrence of taxa. Microtinae, primarily the Varying Lemming (*Dicrostonyx groenlandicus*) was the major prey for both fox species. The Brown Lemming (*Lemmus sibiricus*) and Tundra Vole (*Microtus oeconomus*) [Red Fox only], and Northern Bog Lemming (*Synaptomys borealis*) [Arctic Fox only] were consumed in lower quantities. Several bird species were consumed, primarily by Red Foxes. *D. groenlandicus* was consumed less frequently and birds more frequently by Red Foxes on the mainland (Yukon Coastal Plain) than by those on Herschel Island. The diets of sympatric Arctic Foxes and Red Foxes were similar; however, the Red Fox used more birds and less *D. groenlandicus* than did the Arctic Fox.

Key Words: Arctic Fox, *Alopex lagopus*, Red Fox, *Vulpes vulpes*, food habits, sympatry, competition, Yukon Territory

The diet of the Arctic Fox, *Alopex lagopus*, is restricted compared to that of the Red Fox, *Vulpes vulpes*, (Englund 1965; Chesemore 1968; Macpherson 1969; Stephenson 1970; Hersteinsson and MacDonald 1982; Garrott et al. 1983; Jones and Theberge 1983). This has been attributed to the dependence of Arctic Fox on a less diverse prey fauna (Hersteinsson and MacDonald 1982). The present study compares for the first time the summer food habits of sympatric Arctic Foxes and Red Foxes.

Study Area

The study area included the Yukon Coastal Plain (Bostock 1970) and Herschel Island in the northern Yukon Territory. The physiography and climate of the area have been described by Wiken et al. (1981).

Denning habitat on Herschel Island is characterized by moderately eroded, sloping, gullied terrain and sandy erosional mounds. The two dens sampled on the Yukon Coastal Plain were located in a streamside cutbank and a dune, both in fluvial landforms. Scat samples were collected from three Arctic Fox natal dens (two on Herschel Island at 69°36′N, 139°11′W, and 69°34′N, 139°08′W, one on Yukon Coastal Plain at 69°34′N, 139°40′W) and two Red Fox natal dens (one on Herschel Island at 69°37′N, 138°58′W, one on Yukon Coastal Plain at 69°37′N, 140°56′W). Distances between Arctic Fox and Red Fox dens varied from 8.0 km to 76.5 km.

Cottongrass tussocks (*Eriophorum vaginatum*), moss, ericaceous shrubs and willow shrub (*Salix* spp.) comprise the dominant vegetation on imperfectly drained upland sites in the study area. On sites with better drainage, avens (*Dryas integrifolia*), vetch (*Astragalus* spp.) and Arctic Willow (*Salix arctica*) predominate, commonly interspersed with mud boils (Wiken et al. 1981).

Common small mammal species included Brown Lemming (*Lemmus sibiricus*), Varying Lemming (*Dicrostonyx groenlandicus*), Northern Bog Lemming (*Synaptomys borealis*), Tundra Vole (*Microtus oeconomus*), Northern Red-backed Vole (*Clethrionomys rutilus*), and Arctic Ground Squirrel (*Spermophilus parryii*), the latter on Yukon Coastal Plain only.

The area supports a large and varied breeding avifauna and is important for migration, molting, and staging of the various species (Salter et al, 1980; R. Ward and D. Mossop, unpublished data). At least 50 bird species are summer residents of the study area, including Oldsquaw (*Clangula hyermalis*), Semi-palmated Sandpiper (*Calidris pusilla*), Lapland Longspur (*Calcarius lapponicus*), Baird's Sandpiper (*Calidris bairdii*), Arctic Tern (*Sterna paradisaea*), Northern Phalarope

(*Lobipes lobatus*), Willow Ptarmigan (*Lagopus lagopus*), and American Golden Plover (*Pluvialis dominica*), all of which are abundant.

Methods

Scat collections were made between 29 June and 7 July 1985. Only recent scats (identifiable by their dark and glossy appearance; Macpherson 1969) were collected. Each was labelled with the date, den number and fox species (from observation). The scats were soaked in water or a depilatory, and fragments separated, dried and sorted. Only teeth and bone fragments were analyzed. These were compared with reference skeletons at the Zooarchaeological Identification Centre, National Museum of Natural Sciences (now Canadian Museum of Nature), Ottawa, some of which were obtained during this study. Prey consumption was quantified in terms of percentages of fragments and percent frequency occurrence of taxa. Differences in mean number of identified fragments per scat were tested using Student's t-test. The number of scats containing a food item and the number not containing it were compared between fox species and between areas within species using 2 × 2 contingency table analysis with a Yates correction for continuity (Zar 1984).

Results

Scats found at the dens were of a relatively uniform size and could not be differentiated into those from juvenile or adult foxes using Speller's (1972) classification.

Thirty-one Arctic Fox scats (27 from Herschel Island, four from Yukon Coastal Plain) and 39 Red Fox scats (22 from Herschel Island, 17 from Yukon Coastal Plain) were analyzed (Table 1). Most bones recovered from the scats were broken or damaged to the extent that many were unidentifiable, as gastro-intestinal erosion had modified bone fragment surface features. A large number of mammalian bones were only identifiable to subfamily, although a number of fairly complete elements occurred, e.g., vertebrae, carpals, tarsals, and phalanges. Diagnostic elements identifiable to the species level were primarily restricted to teeth and various long bone elements. Several samples contained avian bones, but the majority of these were unidentifiable fragments. The mean number of all identified fragments per Arctic Fox scat (78.5 ± 39.5 SD) was significantly greater than the mean for Red Fox scats (29.1 ± 26.5 SD; df = 68, t = 6.22, $p < 0.001$).

Microtinae were the most important prey class in both Arctic and Red fox scats, comprising approximately half of all identified fragments. *Dicrostonyx groenlandicus* was the most frequently identified small mammal species in both Red Fox and Arctic Fox scats. The only other small mammals identified, *Lemmus sibiricus* (in both Arctic Fox and Red Fox scats), *Synaptomys borealis* (Arctic Fox) and *Microtus oeconomus* (Red Fox only) occurred at trace levels. Although mammalian hair was not analyzed, cursory examination of hair revealed no evidence of mammals larger than microtinae. Identified bird sub-families were Anatinae (Arctic Fox) and Merginae (Red Fox), and family Anatidae (Red Fox), each of which also occurred at trace levels.

D. groenlandicus and unidentified small mammal remains occurred more frequently in Arctic Fox scats ($X^2 = 21.8$, $p < 0.001$, and $X^2 = 5.3$, $p < 0.025$, respectively) and unidentified bird remains less frequently ($X^2 = 5.3$, $p < 0.05$), than in Red Fox scats. A comparison between Red Fox scats from Herschel Island and the Yukon Coastal Plain showed that scats from the Yukon Coastal Plain contained unidentified small mammal and *D. groenlandicus* less frequently ($X^2 = 6.8$, $p < 0.01$, $X^2 = 9.5$, $p < 0.05$, respectively) and unknown bird remains more frequently ($X^2 = 4.2$, $p < 0.05$). No significant differences were found between frequencies of occurrence of food items between Arctic Fox scats from Herschel Island and the Yukon Coastal Plain.

Discussion

As adults of both the Arctic Fox and the Red Fox are reported to defecate infrequently at the den (Speller 1972; Scott 1943, respectively) the food habits reported here are likely primarily those of juveniles. These may not be representative of other age classes. Frank (1979) found that adult Red Fox scats contained a greater variety of bird remains than did juvenile scats. Kennedy (1980) reported that adult scats contained less caribou carrion than did juvenile Arctic Fox scats.

The greater number of identifiable fragments in Arctic Fox scats relative to those of Red Fox suggests that Red Fox foods are subject to more severe erosional factors during digestion.

Comparisons between different food classes based on percentage of total numbers of identified fragments are complicated by differential digestibility and fragmentation between classes (Scott 1941; Lockie 1959). In feeding trials with Red Foxes, Lockie (1959) showed that birds are under-represented in faeces relative to their true dietary proportions. However, in our opinion comparisons among small mammals are valid, due to the similarity in size, weight, and the proportion of undigestible matter between species.

D. groenlandicus constituted 98% of all small mammal remains identified to species in Arctic Fox scats and 79% in Red Fox scats. The

TABLE 1. Arctic Fox and Red Fox food habits in the northern Yukon Territory expressed as % of total number of bone fragments and % frequency occurrence of food items in scats.

	Arctic Fox						Red Fox					
	Herschel Island 2 dens. n* = 27		Yukon Coastal Plain 1 den, n = 4		Combined 3 dens, n = 31		Herschel Island 1 den, n = 22		Yukon Coastal Plain 1 den, n = 17		Combined 2 dens, n = 39	
Food Item	% of fragments	% freq. occurrence	% of fragments	% freq. occurrence	% of fragments	% freq. occurrence	% of fragments	% freq. occurrence	% of fragments	% freq. occurrence	% of fragments	% freq. occurrence
Mammals:												
Dicrostonyx groenlandicus	7.5	100.0	10.8	50.0	7.6	93.6	5.2	54.6	0.3	5.9	3.9	28.2
Lemmus sibiricus	** t	3.7			t	3.2	0.5	9.1	2.3	23.5	1.0	15.4
Microtus oeconomus									0.3	5.9	0.1	2.6
Synaptomys borealis	t	3.7			t	3.2						
Microtinae, unidentified	51.4	100.0	45.8	75.0	51.2	96.8	45.2	86.4	60.5	88.2	49.4	87.2
Total Microtinae	58.9	100.0	56.6	75.0	58.9	96.8	50.9	90.9	63.4	88.2	54.4	89.7
Small mammal, unidentified	25.0	100.0	12.1	75.0	24.5	96.8	30.4	90.9	10.3	52.9	24.9	74.4
Total Mammal	83.9	100.0	68.7	75.0	83.4	96.8	81.3	90.9	73.7	94.1	79.3	92.3
Birds:												
Anatinae			1.2	25.0	t	3.2						
Merginae							0.1	4.6			0.1	2.6
Anatidae, unidentified							0.2	4.6			0.2	2.6
Total Anatidae			1.2	25.0	t	3.2	0.3	4.6			0.3	2.6
Bird, unidentified	0.3	3.7	3.6	25.0	0.4	6.5	10.3	9.1	12.2	35.3	10.9	20.5
Total Bird	0.3	3.7	4.8	25.0	0.4	6.5	10.6	9.1	12.2	35.3	11.2	20.5
Vertebrate, class unidentified	15.8	66.7	26.5	100.0	16.2	71.0	8.0	31.8	14.2	64.7	9.7	46.2
Number of fragments	2267		83		2350		823		311		1134	

* n = number of scats

** t = trace, or less than 0.1%

proportion of Microtinae among identified fragments was similar in Arctic Fox and Red Fox scats. If it is assumed that proportions of *D. groenlandicus* are similar in both identified and unidentified groups, then *D. groenlandicus* was the most common item in Arctic Fox scats (58% of total number of identified fragments), as well as in Red Fox scats (43%). These proportions are likely underestimated since unidentified small mammals is probably composed mainly, if not wholly, of Microtinae.

Other small mammal species occurred at much lower frequencies in scats of both fox species. The higher proportion of *D. groenlandicus* among small mammals in Arctic Fox scats suggests that they hunt more selectively for this species than does the Red Fox. Conversely, only Red Foxes appeared to take *M. oeconomus*, and they also took a greater proportion of birds. The dietary differences between Red Foxes of Herschel Island and the Yukon Coastal Plain may be attributable to differences in prey availability, to differences in individual preferences of the foxes involved, or to both.

The dietary overlap between Red and Arctic foxes was greater than that reported for Alaska (Eberhardt 1977), however, the Alaska study did not involve exclusively sympatric individuals.

Dicrostonyx is a common food of the Arctic Fox on both island (Chesemore 1968; Kennedy 1980; Garrott et al. 1983) and mainland (Macpherson 1969; Speller 1972) locations in Alaska and the Northwest Territories. Birds also frequently predominate in the diet of the Arctic Fox (Chesemore 1968; Macpherson 1969; Speller 1972; Garrott et al. 1983) but apparently they do not when *Dicrostonyx* is abundant (Macpherson 1969; Kennedy 1980; Garrott et al. 1983). *Lemmus* (Speller 1972) and *Microtus* (Chesemore 1967; Burgess 1984) may also predominate where locally abundant. *Microtus oeconomus* inhabits primarily shrubby areas (Eberhardt 1977) which Arctic Foxes are known to avoid (Garrott et al. 1983). *Dicrostonyx*, the preferred food in the present study, inhabits tundra dominated by low shrubs and herbs, where Arctic Foxes prefer to hunt (Garrott et al. 1983).

The Red Fox diet is comparatively more diverse where its range does not overlap that of the Arctic Fox (Hersteinsson and MacDonald 1982) and this has been attributed to a comparatively less restricted prey base for Red Fox (*ibid*). The present study shows the summer diet of the Arctic Fox to be approximately similar to that of the Red Fox where their ranges overlap, with the Arctic Fox appearing to use slightly more *D. groenlandicus* and the Red Fox using more birds. Little is known of winter food habits of Red Foxes, however, they have been observed scavenging on Ringed Seals (*Phoca hispida*) killed by Polar Bears (*Ursus maritimus*) (Andriashek et al. 1985).

Competition between Arctic and Red foxes extends beyond food habits to denning requirements (C.N.N.S., B.S.G. and R. H. Jessup, unpublished data). The behavioural dominance of the Red Fox over the Arctic Fox in an artificial pen enclosure led Rudzinski et al. (1982) to conclude that Red Foxes should be able to dominate in direct competition for den sites and other limited resources. Although there has been an influx of Red Foxes into Arctic Fox range since the early 1900s (Macpherson 1964; Chirkova 1967), the Red Fox is not known to have completely excluded the Arctic Fox in any sympatric situation.

Although the Red Fox should be able to exclude the Arctic Fox where resources are limited, other factors including a lower ability to withstand low ambient temperatures (Scholander et al. 1950; Irving et al. 1955) or to survive cyclic rabies epidemics could give the Arctic Fox a competitive advantage. The northward movement of Red Fox has been attributed to a warming trend (Chirkova 1967), which would favour the former hypothesis. The ability to acquire winter food may also be limiting the Red Fox's success.

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First Records of False Killer Whales, *Pseudorca crassidens*, in Canada

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A stranding of an adult male False Killer Whale (*Pseudorca crassidens*) on Denman Island, British Columbia, on 3 May 1987, was the first record for Canada. Stomach content analysis revealed small numbers of parasites (*Anisakis* sp.) and recent predation on salmon (*Oncorhynchus* sp.) and squid (either *Berryteuthis magister* or *Gonatopsis borealis*). Osteological evidence and tooth dentine-layer counts (26 growth layer groups) indicate an individual of advanced age. Tissue analysis for heavy metals and pesticides revealed very high levels of mercury (liver, 728 ppm wet weight) and DDE (blubber, 1400 ppm wet weight). A group of at least 12 other *P. crassidens* remained in the inshore waters of Puget Sound, Washington from 3 May 1987 to 2 July 1987, one of which stranded and died. A single individual *P. crassidens* was photographed in Johnstone Strait, B.C., on 22 June 1987, and a different individual *P. crassidens* live-stranded in Ucluelet, B.C., on 28 July 1987, and was returned to the water.

Un mâle adulte pseudorque (*Pseudorca crassidens*) échoué sur la côte de Denman Is., Colombie britannique, le 3 mai 1987 constitue le premier record de cette espèce pour le Canada. L'analyse des contenus stomacaux a révélé un petit nombre de parasites (*Anisakis* sp.), du saumon (*Oncorhynchus* sp.) et du calmar (*Berryteuthis magister* ou *Gonatopsis borealis*). D'après l'évidence ostéologique et des comptes de couche de dentine (26 groupes de couches de croissance), l'individu en question avait atteint un âge avancé. L'analyse des tissus pour les métaux lourds et les pesticides a révélé de très hauts niveaux de mercure (foie, 728 ppm, poids humide) et de DDE (couche graisseuse, 1400 ppm, poids humide). Un groupe d'au moins 12 autres *P. crassidens* fréquentait les eaux de Puget Sound, Washington, du 3 mai 1987 au 2 juillet 1987 et un de leur membres s'échoua et mourut. Un spécimen de *P. crassidens* fut photographié dans le détroit de Johnstone, C.B. le 22 juillet 1987 et un individu différent s'échoua à Ucluelet, C.B. le 28 juillet 1987, mais fut retourné à l'eau encore vivant.

Key Words: False Killer Whale, *Pseudorca crassidens*, first records, stranding, Canada, British Columbia, toxicology.

False Killer Whales (*Pseudorca crassidens*) are highly social odontocetes, widely distributed in tropical and semitropical waters around the world (Sergeant 1982). In the Pacific they frequent waters south of southern California (in the east), and south of northern Japan (in the west; Leatherwood and Reeves 1983). There are several records in the temperate eastern North Pacific south of Washington State, and one animal was collected in Puget Sound, Washington, in 1937 (Scheffer and Slipp 1948). There is also a reported sighting from Prince William Sound, Alaska (Matkin *in* Leatherwood et al. 1982), of a single animal in 1976, but it was not well documented. Some authors (Purves and Pilleri 1978) show a record from Davis Strait off Baffin Island, presumably from True (1889); however, this record is not substantiated (Miller 1920). There are no records from British Columbian waters (Pike and MacAskie 1969) or from the east coast of Canada (Leatherwood et al. 1976). Herein we describe the first records of *P. crassidens* in Canada.

On 8 May 1987, we were informed of a stranded whale on Denman Island, British Columbia (49°27′N, 124°41′W). The whale was first discovered by a Denman Island resident on 3 May 1987 and was later identified as a male *P. crassidens* (Figure 1).

Body and cranial characters were measured according to Norris (1961) and Ross (1984), and a gross post mortem examination was performed. Selected body measurements (linear measurements in cm) were: total length, 462; tip of upper jaw to tip of dorsal fin, 195.5; anterior insertion of flipper to tip, 61; axilla to tip of flipper, 42; dorsal fin base width, 33; flipper width (maximum), 23; flukes (tip to tip), 96.5; dorsal fin height, 33; girth on a transverse plane intersecting axilla, 99; maximum girth, 127; girth on a transverse plane intersecting anus, 79. Selected cranial measurements (in mm) were: condylobasal length, 595; rostrum length, 297; basal width of rostrum, 208; number of teeth, upper right, 8; number of teeth, upper left, 8; length of tooth row, upper right, 229; length of tooth row, upper left, 233; number of teeth, lower right, 9; number of teeth, lower left, 8; length of tooth row, lower right, 242; length of tooth row, lower left, 224; length of mandible, 501;

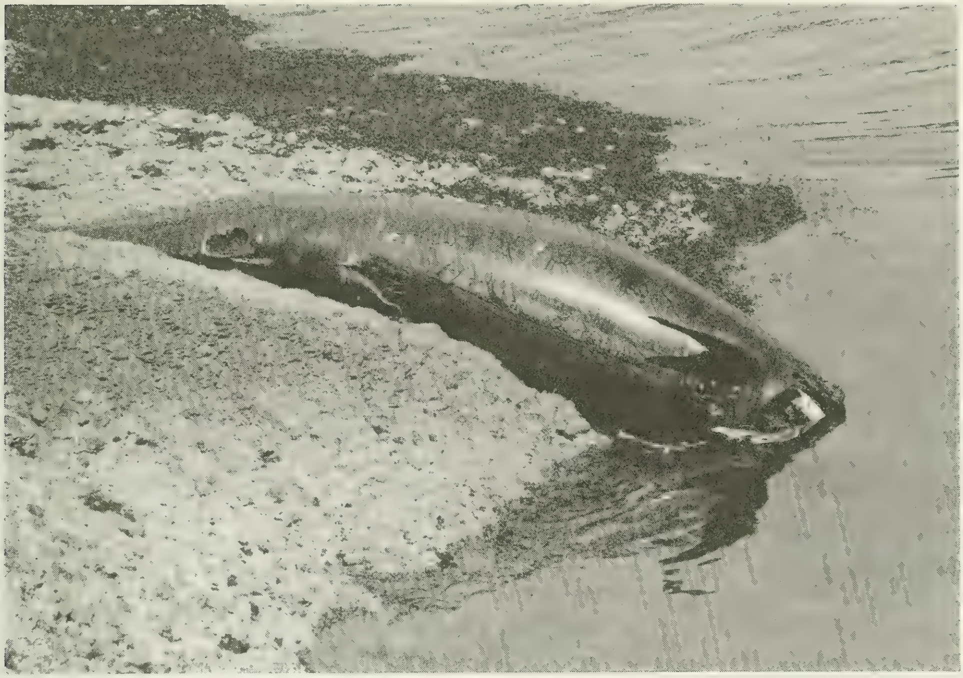

FIGURE 1. Male adult *Pseudorca crassidens* stranded on Denman Island, Canada (BCPM 16149). Photo by Robin W. Baird.

height of cranium between basioccipital and the vertex, 227. The rostrum and anterior two-thirds of the mandible were removed earlier by a local resident, but were later recovered. The lungs, trachea, and major airways were all clean and air-filled with the same degree of decomposition as the rest of the body. This indicated that the whale did not drown and possibly stranded while alive. Blubber, liver, kidney, and brain samples were collected for pesticide and heavy-metal analysis (Table 1). Fecal material was collected for oocyst flotation. The right testicle was removed for weighing and measuring, and the entire skeleton was collected and deposited in the collections of the Royal British Columbia Museum (BCPM 16149). Histological examination of tissues was not possible because of the advanced decomposition.

The stomach contained a large amount of material and was removed intact for analysis. Examination of the stomach revealed several large, healing ulcers. The stomach contained 55 salmon vertebrae (*Oncorhynchus* sp.), vertebral rays, and 29 fish eye lenses. The only previous record for salmon as prey of *P. crassidens* is an undocumented report of salmon vertebrae from the stomach of a specimen from Washington State (Scheffer and Slipp 1948). Thirty squid beaks (either *Berryteuthis magister* or *Gonatopsis borealis*) also were identified from stomach contents. The undigested condition of the salmon vertebrae indicated that the animal had been feeding within about 12 hours before stranding. Fleshy remains of squid also were present, indicating that they had been ingested shortly before death. Small numbers of larval *Anisakis* sp. (probably *A. simplex*) were identified from the stomach. *Anisakis* sp. oocysts were recovered by flotation from fecal material.

Radiographs of a pectoral flipper and the coccygeal vertebrae revealed closure of all epiphyses, indicating maturity. The pulp cavity of all teeth were completely occluded, and all teeth showed moderate amounts of wear. Heavy lingual undercutting, greater than 40% of the width of the tooth, was present in four teeth, with moderate lingual undercutting present in six others. Small amounts of wear resulting from lateral movements have been found in teeth of mature *P. crassidens*, with dentine layer counts of 18 and 13 or 14, indicating that movement causing lateral wear is relatively infrequent (Ross 1984). Dentine layer counts from the middle mandibular teeth showed at least 26 growth layer groups, with each group characterized by a broad dark layer, followed by a thin light layer. Examination of the cleaned skull and skeleton revealed extensive degenerative arthropathy of both occipital condyles and the first

TABLE 1. Tissue analysis for heavy-metals and pesticides in a False Killer Whale, *Pseudorca crassidens*, stranded 3 May 1987 on Denman Island, British Columbia.[1]

	Tissue (ppm wet weight)			
Contaminant	Liver	Kidney	Brain	Blubber
Selenium	153			
Copper	15	4		
Zinc	154	21		
Iron	141	23		
Manganese	6.6	1.2		
Lead	< 1	< 1		
Cadmium	1.1	0.2		
Arsenic	< 0.5	< 0.5		
Calcium	61	55		
Magnesium	255	172		
Mercury	728	72	47	
PCB total	5.4		2.7	160
DDE	50		29	1400
DDD	3.4		0.14	4.8
Other organochlorines	< 0.05		< 0.05	< 0.05

[1] Analysis by Veterinary Pathology Laboratory, Abbotsford, British Columbia.

cervical vertebra, and fusion of the humeral and ulnar bones of the flippers.

Sergeant (1982) estimated that male *P. crassidens* mature at about 500 cm in body length. The whale reported here at 462 cm is small in comparison. The testis dimensions (43 by 18 by 13 cm) and weight (4.5 kg) are small compared to those of mature specimens described by Fraser (1936), and Odell et al. (1980). However, osteological evidence suggests an individual of advanced age.

Tissue samples of blubber, liver, kidney, and brain, analyzed for heavy metals and pesticides, revealed unusually high levels of mercury and organochlorines (Table 1). According to Gaskin (1982), the highest reported mercury levels in cetacean liver were from Common Dolphins (*Delphinus delphis*) in the western Mediterranean, at levels of greater than 604 ppm wet weight. Levels of mercury in the liver, kidney, and brain in our specimen were 728, 72, and 47 ppm, respectively (wet weight).

Levels of DDE in the blubber were 1400 ppm (wet weight). Because *P. crassidens* has a semitropical distribution, and does not frequent coastal waters, one would expect that exposure to chlorinated hydrocarbons and their concentration in the tissues would be low (Gaskin 1982). Although advanced age could account for higher accumulation of organochlorines, levels in this individual were higher than values obtained for other cetaceans (Gaskin 1982; Calambokidis et al. 1984).

The stranded individual described here may have originated from a group of at least 12 *P. crassidens* that were first seen in the inshore waters of Puget Sound, Washington State on 3 May 1987, the same day its body was first discovered. The Puget Sound pod remained in the area until 2 July 1987 (Osborne et al. 1988). Another presumed member of this pod, a juvenile, stranded and died in Puget Sound on 5 May 1987.

Since the 3 May 1987 stranding, two other *P. crassidens* were sighted in British Columbia. A single individual was observed and photographed (BCPM photo 1170) in northern Johnstone Strait, B.C., (50° 35′N, 126° 52′W) on 22 June 1987, and a 3.5-metre individual stranded alive in shallow water in Ucluelet, B.C., (49° 58″N, 125° 34′W) on 28 July 1987 and was successfully returned to deeper water (BCPM photo 1174). Although both individuals had distinctive natural markings allowing for individual photo-identification (Bigg et al. 1986), comparison with photographs of the 12 *P. crassidens* from Puget Sound in May and June of 1987 revealed no matching patterns.

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Feeding Ecology of Western Sandpipers, *Calidris mauri*, and Dunlins, *C. alpina*, during Spring Migration at Hartney Bay, Alaska

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The food habits and feeding ecology of Western Sandpipers (*Calidris mauri*) and Dullins (*C. alpina pacifica*) were compared during two spring migrations at Hartney Bay, Alaska. Their use of the intertidal mud flats overlapped in space and time, but we found important behavioral and dietary differences. Dunlins rested during high tides and fed most heavily during falling tides, usually at the water's edge. Western Sandpipers tended to feed continuously between successive high tides, and were not concentrated at the water's edge. When few or no Dunlins were present, Western Sandpipers shifted their distribution so that a greater proportion fed near the water's edge. Western Sandpiper diets were diverse; Dunlins relied most heavily on a single species of clam, *Macoma balthica*. The number of *Macoma balthica* in the size range taken most frequently by Dunlins decreased over the course of the migration.

Key Words: Dunlin, *Calidris alpina*, Western Sandpiper, *Calidris mauri*, clam, *Macoma balthica*, food habits, feeding ecology, migration, evolution, Alaska.

Natural selection during the non-breeding season may act to regulate shorebird populations and to favor morphological and behavioral differences among species (Recher 1966; Baker and Baker 1973). Competition for food or feeding space during migration may be especially important in these processes (Recher 1966; Holmes and Pitelka 1968; Burger et al. 1977; Duffy et al. 1981; Schneider and Harrington 1981). There have been, nonetheless, few comparisons of the ecology of closely related or morphologically similar species strictly during migration (e.g., Bengtsson and Svensson 1968; Wishart et al. 1981). Some investigators have invoked competition to explain differences in the spatio-temporal segregation of *Calidris* sandpipers (Recher 1966; Recher and Recher 1969; Page et al. 1979), yet behavioral and ecological differences among co-existing species are not, in themselves, evidence that such differences result from competition (Wiens 1977).

The Copper-Bering river delta system in south-central Alaska is a migration stopover point simultaneously important to Western Sandpipers (*Calidris mauri*) and Dunlins (*C. alpina pacifica*) (Senner et al. 1981). This paper compares the food habits and habitat use of these species during spring migration, drawing on data originally gathered to describe the use of the Copper River Delta by shorebirds in relation to oil development and transportation in the northern Gulf of Alaska (Senner 1977, 1979). The results of this study also bear on the potential importance of migration in the evolution of interspecific differences among shorebirds.

Study Area and Methods

Hartney Bay (60°30′N, 145°52′W) is located in Orca Inlet and sheltered by the Heney Mountains at the western fringe of the Copper-Bering river delta (C-BRD) system on the northern Gulf of Alaska coast (Figure 1; also Figure 1 *in* Senner et al. 1981: 273). The physiography, climate, and avian habitats of the region were described by Isleib and Kessel (1973). Tides are semidiurnal, averaging 3.5 m, with a marked inequality between successive low waters. The bay is used most heavily by shorebirds when tidal waters cover the 100s of km^2 of flats exposed at low and mid-tide stages in the main Copper River Delta to the east. This is especially true when strong winds or storms amplify tides on the outer beaches.

Data presented in this paper were gathered primarily during 27 April — 27 May 1976 and 30 April — 26 May 1977. Some data were gathered during 2-6 May 1975.

Transects

Two transects were established perpendicular to the tide for sampling invertebrates, censusing shorebirds, and collecting sandpipers for analyses of their food habits. The transects, measuring 600 x 50 m (I) and 300 x 50 m (II), were located where

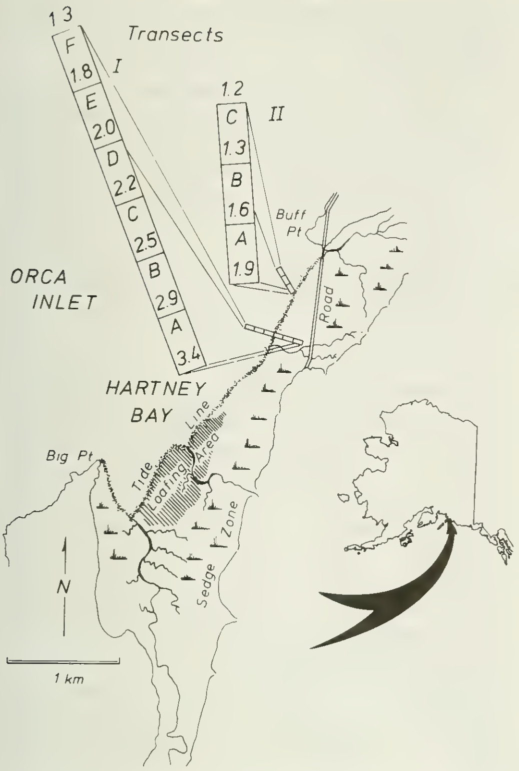

FIGURE 1. Map of the Hartney Bay study site, with an inset showing the location of Hartney Bay in Alaska. The tide line approximates a 3/4 high tide. The enlarged transects show transect numbers, zones, and approximate tidal elevations (m).

feeding shorebirds were concentrated and easily visible from the Hartney Bay road (Figure 1). Because of the distance to it (ca. 1 km) and low-density usage by shorebirds of the lower intertidal zone, the transects did not extend to the mean low water line.

On 1-2 May 1976, prior to the main sandpiper migration, and on 25 May, after the main migration, we sampled the invertebrates on each transect using a stratified random scheme and a 5 x 20 x 3 cm steel frame (*details in* Senner 1977). Faunal samples were washed through a 1 mm screen, and all specimens were sorted, counted, weighed, and identified to the lowest taxonomic level possible. Lengths of all bivalve molluscs were measured to the nearest mm.

Based on the sizes of *Macoma balthica* taken as prey by the sandpipers, we divided the *Macoma* found in the invertebrate samples into three size classes. Within each transect, zone (except A in transect I), and size class, we compared the mean number of *M. balthica* for the pre- and post-migration samples, using a t-test for paired comparisons (Sokal and Rohlf 1981).

In 1976, we censused shorebirds on the two transects 113 times; in 1977, 122 times. Hourly, from high to low or low to high tides, we recorded the number of birds in the exposed zones of each transect. We tallied the respective numbers of Dunlins and Western Sandpipers for each transect and averaged those totals over all of the censuses recorded at each tide time (-5, -4 . . . 0 [= dead low water] . . . + 5, + 6 h). On transect I there were 11-23 censuses for each tide time; on transect II, 3-15 censuses. The averages were then expressed as percentages of the total of the 12 hourly averages for each species. For those censuses in which the tide had not completely exposed the transect, but during which at least two zones were all or partly exposed, we used Wilcoxon's signed-rank test for two groups with paired observations (Sokal and Rohlf 1981) to compare the proportion of sandpipers counted in the zone "containing" the water's edge versus the proportion in the zone or zones above the tide line.

Stomachs

Our analyses of foods taken are based on stomach contents of 87 Dunlins and 61 Western Sandpipers collected at Hartney Bay in the study periods, 1975-1977. For the analysis of food habits — but not weights of stomach contents — we only used stomachs from sandpipers shot while actively feeding. We removed the contents of each stomach (proventriculus and gizzard) within 10 minutes after collection, and preserved them in buffered formalin. In the laboratory we weighed all contents of each stomach, and sorted and counted key parts representing single organisms. We measured the lengths of whole organisms and weighed them separately. Seeds, grit, and vegetable matter were not considered food items (Tuck 1972), but were included in the total weights of stomach contents.

We estimated the biomass of food items ingested by individual sandpipers by multiplying the number of organisms in each taxon by appropriate mean dry weights determined from representative specimens from the faunal or stomach samples (Holmes 1966; Senner 1977). Female Dunlins take larger *M. balthica* than do male Dunlins (Senner 1977), so we adjusted the estimate of the biomass (soft parts only) of this prey by the proportions of small (≤ 5 mm) and large (> 5 mm) intact individuals in the stomachs of the respective sexes.

Frequency of occurrence of food items was calculated after Hartley (1948); per cent composition of the total food items was calculated on a biomass basis (Holmes 1966). We compared overlap in diets by summing the per cent values shared for any and all prey classes of the two sandpiper species (Holmes and Pitelka 1968). We used the Tukey-Kramer method to compare the mean wet weights of the stomach contents, by species and tide stage (Sokal and Rohlf 1981).

Results

Invertebrate Prey Base

Considering the pre-migration samples for the two transects together, 5 species of bivalve molluscs (Pelecypoda) accounted for 89.2% of the biomass (mg dry weight); 12 species of polychaete worms (Polychaeta) accounted for 10.4% of the biomass. One bivalve, *M. balthica*, comprised 88.4% of the total biomass. The next most important species was a polychaete, *Nephtys ciliata*, which accounted for 6.2% of the total biomass. Two amphipods (Amphipoda), *Anisogammarus* species and *Corophium salmonis*, made up $< 1\%$ of the biomass. Senner (1977) presented these results in detail.

TABLE 1. Frequency of occurrence (%) of prey taxa represented in the stomachs of Western Sandpiper ($N = 61$) and Dunlin ($N = 87$) collected at Hartney Bay.

Prey Taxon	Western Sandpiper	Dunlin
Polychaeta		
Abarenicola sp.	-	2
Arachnida		
Acararina, unidentified	2	-
Crustacea		
Crustacea, unidentified	3	2
Harpacticoida, unidentified	5	-
Campylaspis sp.	3	-
Amphipoda, unidentified	3	10
Gammaridae, unidentified	-	2
Anisogammarus sp.	-	2
Corophium salmonis	20	18
Insecta		
Insecta, unidentified adult	-	3
Diptera, unidentified adult	2	-
Chironomidae, unidentified larva	33	8
Dolichopodidae, unidentified larva	30	15
Gastropoda		
Gastropoda, unidentified	5	2
Littorina sp.	3	2
Pelecypoda		
Pelecypoda, unidentified	11	2
Mytilus edulis	56	18
Clinocardium sp.	23	13
Astarte sp.	2	-
Macoma balthica	52	91
Mya sp.	39	36
Veneridae, probably *Transenella tantilla*	8	7
Animal Fragments, unidentified	7	7

Food Habits

About the same number of prey taxa were found in Western Sandpiper and Dunlin stomachs (Table 1), but the food habits of the former species were more diverse (Figure 2). Dunlins relied heavily on *M. balthica*, whereas at least three species of bivalve molluscs and two species of larval dipterans were important to Western Sandpipers. Although polychaetes were well represented in the Hartney Bay infauna, they were not important in the diet of either sandpiper species.

The per cent overlap in the prey of Dunlins and Western Sandpipers on a biomass basis was 27.3%. Dunlins, however, took significantly larger prey than did Western Sandpipers. The mean lengths (± SE) of the amphipod *C. salmonis* taken by Dunlins and Western Sandpipers at Hartney Bay and two other sites in the C-BRD system were 6.3 mm ± 0.44 (range = 2-12 mm, $n = 30$) and 3.8 mm ± 0.16 (range = 2-5 mm, $n = 22$), respectively ($t_s = 4.76$, $P < 0.05$).

Combining all pelecypod species, the mean lengths taken by Dunlins were 5.7 mm ± 0.27 (range = 2-11, $n = 71$) compared to 3.2 mm ± 0.15 (range = 2-6 mm, $n = 61$) by Western Sandpipers ($t_s = 7.79$, $P < 0.05$). Among 49 intact *M. balthica* ingested by Dunlins, 57% were in the 7-12 mm class; 33%, 4-6 mm; and 10%, 1-3 mm. For Western Sandpipers, 3 of 4 intact *M. balthica* were in the 4-6 mm range and 1 was in the 1-3 mm range.

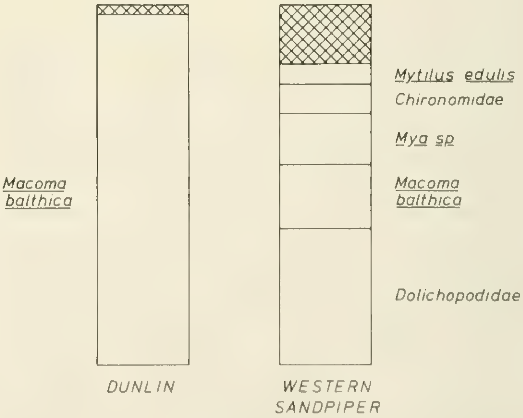

FIGURE 2. Stomach contents of Western Sandpipers and Dunlins collected at Hartney Bay, expressed as per cent composition of total estimated prey biomass. Hatched bars show the sum of food items which, individually, comprised less than 5% of total food items.

Prey Depletion

On both transects the mean number of *M. balthica* per zone in the 7-12 mm class decreased in the post-migration invertebrate samples (Table 2). For the 1-3 mm range there were no significant differences, but for the 4-6 mm class there were mixed results. On transect I there were significantly fewer *M. balthica* following migration; on transect II, there was no difference.

Habitat Use

On high tides, Dunlins stopped feeding and routinely rested in large, mixed-species (e.g., with *Calidris canutus* and *Limnodromus* species) aggregations, just above the water's edge (Figure 1). Most Western Sandpipers continued feeding, although less intensively, through the high tide stages, using still-exposed mud and sedge flats. Even Western Sandpipers that joined roosting flocks tended to feed intermittently among the resting birds. Within 1 h following high tides, most sandpipers of both species resumed feeding (Figure 3). On receding tides Dunlins — but not Western Sandpipers — showed a significant tendency to concentrate their feeding efforts about the water's edge (Table 3).

At low tides, both species dispersed over the flats and sometimes left Hartney Bay entirely. Small numbers of Western Sandpipers, but rarely Dunlins, continued to forage at small pools of water in the mid- and upper-intertidal zone (Figure 3), probably taking amphipods and insect larvae. On 24 of 26 censuses when transect I was entirely exposed, feeding Western Sandpipers chose zones C and D, the zones in transect I having the greatest invertebrate biomasses (1976 data only; Senner 1977).

As rising tides decreased the exposed tide flats, some birds left Hartney Bay and Orca Inlet, presumably to resume their migration to the northwest or to seek alternative roosting or feeding sites elsewhere in the C-BRD system. These departures were often balanced by new arrivals. Sandpipers in the bay, often numbering in the tens of thousands (Senner et al. 1981), became progressively concentrated above rising tide lines. Dunlins still showed a significant association with the water's edge, although less strong than on falling tides (Table 3). As on falling tides, Western Sandpipers showed no significant affinity to the water's edge on rising tides.

We conducted 14 censuses on rising and falling tides in which Western Sandpipers were present and Dunlins were largely absent (< 15% of the combined total) from the transect. In nine censuses a higher proportion of Western Sandpipers was found in the zone with the tide line (Table 3). The intra-habitat distribution of Dunlins did not change in the absence of Western Sandpipers.

TABLE 2. Mean numbers of *Macoma balthica* per sample, by size class, before and after the spring shorebird migration on two transects at Hartney Bay. Values shown are $\bar{x} \pm 1$ SE. Following each group, t_s for a t-test for paired comparisons is shown. For each zone $n = 6$, except in I-B, where $n = 4$. An asterisk (*) indicates a significant difference, $P < 0.05$, between pre- and post-migration means.

	Transect I			Transect II		
Size Class (mm)	Zone	Sample Period Pre	Post	Zone	Sample Period Pre	Post
1-3	B	0.8 ± 0.8	0.8 ± 0.8	A	2.2 ± 0.5	5.5 ± 2.2
	C	1.8 ± 0.7	2.8 ± 0.7	B	2.7 ± 1.3	7.7 ± 1.6
	D	3.0 ± 1.0	1.2 ± 0.6	C	2.0 ± 0.9	3.2 ± 0.4
	E	3.2 ± 1.0	5.8 ± 1.2		$t_s = 2.88$, df = 2	
	F	2.3 ± 0.4	7.2 ± 4.6			
		$t_s = 1.35$, df ± 4				
4-6	B	1.5 ± 1.2	0.5 ± 0.3	A	3.3 ± 0.8	0.7 ± 0.3
	C	5.2 ± 1.1	4.5 ± 1.0	B	2.2 ± 0.9	2.7 ± 0.8
	D	3.3 ± 0.8	2.3 ± 0.4	C	1.0 ± 0.6	0.8 ± 0.2
	E	1.3 ± 0.5	0.7 ± 0.4		$t_s = 0.827$, df = 2	
	F	1.0 ± 0.4	1.5 ± 0.6			
		$t_s = 2.47$*, df ± 4				
7-12	B	3.8 ± 3.8	2.0 ± 2.0	A	6.3 ± 1.7	1.8 ± 0.5
	C	16.3 ± 1.8	12.3 ± 2.4	B	3.3 ± 0.6	0.7 ± 0.5
	D	7.7 ± 1.6	1.3 ± 0.6	C	1.8 ± 0.6	0.3 ± 0.2
	E	1.3 ± 0.6	0.8 ± 0.3		$t_s = 3.27$*, df = 2	
	F	2.7 ± 1.5	0.5 ± 0.2			
		$t_s = 3.21$*, df ± 4				

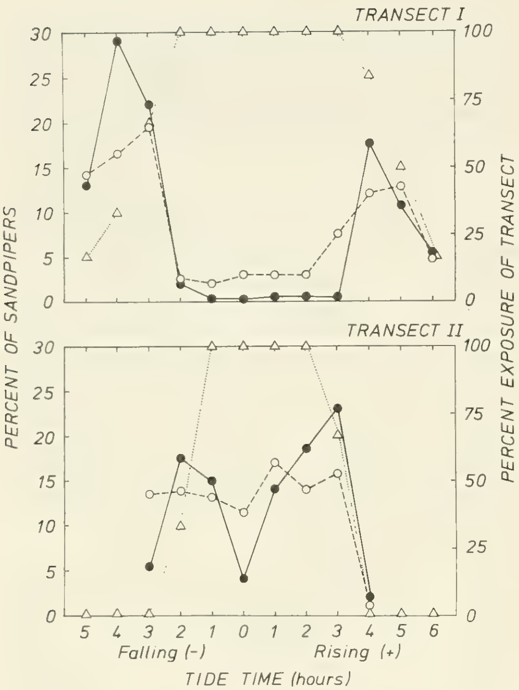

FIGURE 3. Proportions (%) of the average numbers of Western Sandpipers (open circles) and Dunlins (closed circles) using two Hartney Bay transects in relation to tide time and per cent exposure (triangles) of the transects.

Weights of Stomach Contents

The mean weights of stomach contents may provide an indication of feeding activities in relation to tides or other factors (e.g., Couch 1966). Mean weights of stomach contents for both species were lowest among individuals collected on high tides, indicating reduced food intake at this tidal stage (Table 4). The mean weights of Dunlin stomach contents increased sharply on the falling tide, but showed no significant change between falling and rising tides. This pattern suggests that the rate of intake diminishes after the tide has receded. The mean weights of Western Sandpiper stomach contents did not increase significantly between high and falling tides, but did between falling and rising tides (Table 4). This pattern indicates that Western Sandpipers continued to feed actively through the low and rising tide stages, before slowing — but not necessarily stopping — their feeding during high tides.

Discussion

From late April to mid-May, millions of migrating Dunlins and Western Sandpipers stop to feed and rest in the C-BRD system (Isleib and Kessel 1973; Isleib 1979; Senner et al. 1981). In most years the persistence of snow and ice on higher wetlands restricts feeding by Dunlins and Western Sandpipers to intertidal habitats (Senner et al. 1981). Tens of thousands to one million or more sandpipers of both species may simultane-

TABLE 3. Number of censuses, by species and tide stage, in which the proportion of sandpipers in the transect zone "containing" the water's edge exceeded the proportion of sandpipers in the zone or zones above the water's edge. Values shown are the number of censuses, the total number of censuses (n), and t_s for Wilcoxon's signed-rank test. An asterisk (*) indicates statistical significance, $P < 0.05$.

Species	Rising	Falling	Rising & Falling
Western Sandpiper vs. Western Sandpiper	10 (26) 156.5	13 (28) 186.5 -	-
Dunlin vs. Dunlin	14 (21) 65.0*	23 (27) 17.0*	-
Dunlin vs. Western Sandpiper[a]	9 (18) 30.0*	20 (23) 0.0*	-
Western Sandpiper vs. Western Sandpiper (absent Dunlin)[b]	-	-	9 (14) 20.6*
Dunlin vs. Dunlin (absent Western Sandpiper)	-	-	7 (10) 15.0*

[a] Comparison of number of censuses in which the proportion of Dunlins in the zone containing the water's edge exceeded the proportion of Western Sandpipers in that same zone.

[b] The species in parentheses comprised < 15% of the combined total of Western Sandpipers and Dunlins on the entire transect for each census.

TABLE 4. The mean wet weights (mg) of stomach contents, by tide stage, from Western Sandpipers ($N = 49$) and Dunlins (80) collected at Hartney Bay. Values shown are $\bar{x} \pm 1$ SE, (n). An asterisk (*) indicates that adjacent pairs of means differ significantly, $P < 0.05$.

Species	High[a]		Falling		Rising
Western Sandpiper	107 ± 10.3		136 ± 11.6	*	204 ± 21.3
	(15)		(22)		(12)
Dunlin	190 ± 17.8	*	358 ± 26.4	*	397 ± 22.9
	(27)		(31)		(22)

[a] High tide = the period 1 h before through to 1 h after actual high tide.

ously use the intertidal zone of the C-BRD system (Isleib 1979). Beyond their large numbers in, and overlapping use of, the C-BRD system, Dunlins and Western Sandpipers are broadly sympatric and extensively synchronous during spring and fall migrations and on their breeding grounds (Senner 1979; A.O.U. 1983).

The mean body mass of Western Sandpipers is about 44% of the Dunlin mean; culmen length is about 64% of the Dunlin mean (calculated from Table 1 in Senner et al. 1981: 276). Based on Recher (1966), Baker and Baker (1973), and Baker (1977), it is predictable that Western Sandpipers take smaller and more diverse prey than Dunlins. The larger Dunlin is more stenophagic, takes larger prey than Western Sandpipers, and feeds less continuously than Western Sandpipers (cf. Burger et al. 1977: 756).

Western Sandpipers feed either on the surface or by probing (Ashmole 1970), and exploit a wider range of intertidal habitats than do Dunlins. Because of its longer beak and legs, the Dunlin is better able to exploit the flooded area immediately below the tide line. Preference for the water's edge as it moves across a tidal flat suggests that it is a prime place for capturing such prey as *M. balthica* (Vader 1964; Recher 1966; Prater 1972).

The behavioral and dietary differences we documented for these congeners at Hartney Bay are consistent with other comparisons during the nonbreeding season (Couch 1966; Recher 1966; Recher and Recher 1969; Holmberg 1975; Gerstenberg 1979). Our results also parallel comparisons of other *Calidris* species "pairs" in which the larger species made greater use of the area about the water's edge and had a more selective diet (Bengtsson and Svensson 1968; Ashmole 1970; Thomas and Dartnall 1971). Thomas and Dartnall (1971: 24) also noted a "small change" in the intrahabitat distribution of the smaller Red-necked Sandpipers (*C. ruficollis*) in the absence of the larger Curlew Sandpipers (*C. ferruginea*).

The Dunlin is a less aggressive species than the Western Sandpiper (Recher and Recher 1969), and we saw little interspecific aggression. Yet the mere presence of substantial numbers of Dunlins may have excluded Western Sandpipers from the space near the tide line (cf. Goss-Custard 1980). Wishart et al. (1981) noted that in mixed flocks of feeding shorebirds (three species), dominance was related directly to body size.

An altered pattern of resource usage in the presence or absence of other species is not necessarily evidence of competition (MacNally 1983). Yet the shift in the Western Sandpipers' feeding microhabitat in the absence of Dunlins and the likelihood of a decreasing supply of *M. balthica* during the migration (Table 2) indicate conditions in which competition may occur.

To the extent that interspecific competition for feeding space and prey occurs, it does so within the context of a highly variable environment [Burger (1984) described abiotic factors influencing shorebird migration]. In some years migrant shorebirds may encounter severe limitations in food availability or quality at one or more of their traditional stopping points. Weather and extraordinary tides affect the availability of feeding habitats (Gerstenberg 1979; Page et al. 1979) as well as the behavior and availability of invertebrate prey (e.g., Evans 1976). Weather and such other factors as salinity also affect the recruitment and survival of intertidal invertebrates potentially available as prey (e.g., Crisp 1964).

Limitations in food supply may decrease foraging success so that some shorebirds will arrive on their breeding grounds with depleted reserves of depot lipids or other body constituents. Such reserves may be important to reproductive success at high latitudes (e.g., Irving 1960; Raveling 1979), where severe weather may delay reproductive activities and reduce food availability. Behavioral and morphological characteristics that enable individual migrants to forage more successfully — and arrive with greater fat reserves — than their conspecifics can be translated into adaptations at the population level. The few days spent at one or a few critical stopping areas along a migration route are spatio-temporal "bottlenecks" (Myers et al. 1987) in which variable environmental conditions — supplemented or reinforced by competitive interactions — may exert a strong selective influence on shorebird populations.

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Population Dynamics of the Arctic Fox, *Alopex lagopus*, on Banks Island, Northwest Territories

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The age structure, survival, and physical condition of the Arctic Fox (*Alopex lagopus*) population on Banks Island, Northwest Territories, was studied from 718 animals trapped at Sachs Harbour from 1974 to 1978. The size of the Arctic Fox harvest varied between years. An increase in the availability of carrion from Ringed Seals (*Phoca hispida*) killed by Polar Bears (*Ursus maritimus*), and possibly from lemmings (*Dicrostonyx groenlandicus, Lemmus trimucronatus*), may have influenced reproductive success and a subsequent increase in the Arctic Fox harvest in 1973-74, 1976-77, and 1977-78. Annual survival of adult Arctic Foxes averaged 58% and was about double that of juveniles. Maximum recorded longevity was six years for males and seven years for females. Within age classes, survival and condition of males and females were similar. Similarities in trends of age distribution between the foxes of the coastal and inland regions of Banks Island were thought to be due to mixing of animals from both areas. The body condition of foxes of all age and sex classes were similar in both coastal and inland regions.

Key Words: Arctic Fox, *Alopex lagopus*, Ringed Seal, *Phoca hispida*, scavenging, population dynamics.

The Arctic Fox (*Alopex lagopus*) is common throughout its range though numbers may fluctuate substantially, usually in response to variations in the number of small mammals. It occurs in two color phases, white and blue, with the white phase predominating in the Canadian Arctic. It is of great economic importance in the Canadian Arctic, especially at Sachs Harbour on Banks Island, Northwest Territories, which is the most productive Arctic Fox trapping area in Canada (Usher 1971a).

The Arctic Fox is also an important component of both the terrestrial and marine ecosystems. On land, it preys on the Collared Lemming (*Dicrostonyx groenlandicus*), the Brown Lemming (*Lemmus trimucronatus*), and small birds and their eggs, as well as scavenging Caribou (*Rangifer tarrandus pearyi*) remains (Chesemore 1968b; Speller 1972). On the sea ice during the winter and spring, the Arctic Fox scavenges the remains of Ringed Seals (*Phoca hispida*) and Bearded Seals (*Erignathus barbatus*) killed by Polar Bears (*Ursus maritimus*) (Stirling and Smith 1977) and, in some years, it also preys upon Ringed Seal pups in their subnivean birth lairs (Smith 1976).

Studies of the biology and ecology of Arctic Foxes have been done in most arctic regions (Braestrup 1941; Chitty and Chitty 1945; Pulliainen 1965; Chesemore 1967, 1968a, 1968b; Macpherson 1969; Shilyaeva 1971; Usher 1971b; Speller 1972; Urquhart 1973a, 1973b; Smith 1976; Wrigley and Hatch 1976; Grue and Jensen 1976; Eberhardt and Hanson 1978; Bradley et al. 1981; Eberhardt et al. 1982; Eberhardt et al. 1983; Garrott et al. 1983; Hammill 1983). In this study, we analyzed the age composition of samples of Arctic Foxes trapped during the winter on Banks Island from 1974-75 through 1977-78 and tried to evaluate the relative importance of different food sources to the recorded fluctuations in the total harvest.

Methods

Banks Island, Northwest Territories, is located between 71° and 74° North, and 115° and 125° West (Figure 1). The central area is composed of flat grassy plains with hills and plateaus 300-450 m above sea level, providing ideal habitat for Arctic Foxes and lemmings (Manning and Macpherson 1958). Urquhart (1973a, 1973b) found the greatest density of Arctic Foxes in the hilly areas between the major rivers in the southwest. Usher (1971b) gives a more complete description of the geography of Banks Island. Freeze-up in the eastern Beaufort Sea usually begins between late September and early October, while break-up begins in mid-May.

Arctic Fox carcasses were collected from Inuit trappers on Banks Island during the winters of 1974-75 through 1977-78. The samples were not large enough to facilitate monthly analyses so only annual (November through April) comparisons were possible. In addition to those taken by trappers, 12 Arctic Foxes were shot on the sea ice in April 1973 and 1974.

The sex and condition of the trapped Arctic Foxes were recorded at the time the skulls were separated from the carcasses for age determina-

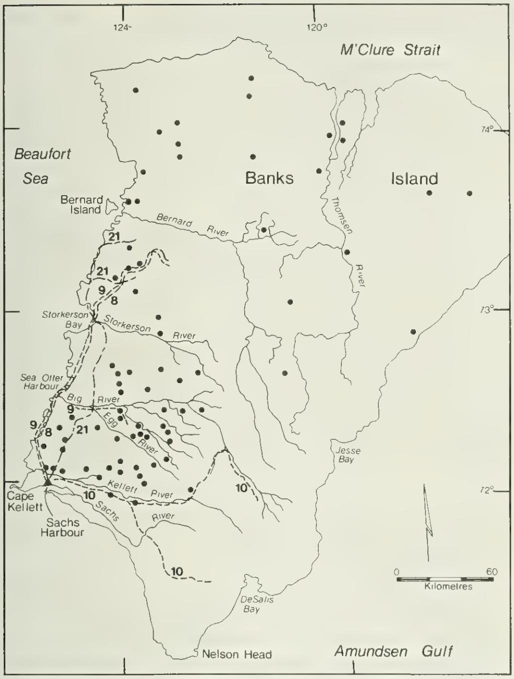

FIGURE 1. Locations of Inuit traplines used for collection of Arctic Fox specimens, 1974-78 (dotted lines), and Arctic Fox den sites (solid dots). From Usher (1971a) and Urquhart (1973a).

tion. For some foxes, trappers saved only skulls so that age and year of capture, but neither sex nor condition, were known. Condition was subjectively assessed on a scale of 1 to 3, thin foxes being condition 1 and fat foxes being condition 3.

Canine teeth collected from the jaws of 718 Arctic Foxes were decalcified, thin-sectioned, and examined under a light microscope (Stirling et al. 1977). Age was determined by counting annual lines in the cementum (Grue and Jensen 1976; Bradley et al. 1981). Arctic Foxes with no incremental lines (age 0+) were classified as juveniles. All others (age 1 year and over) were classified as adults, since the Arctic Fox matures at 10 months of age (Macpherson 1969). The diameter of the pulp cavity of the tooth was also useful in confirming the age of animals less than one year old, because the pulp cavities of juvenile Arctic Foxes are generally much larger than those of adults (Bradley et al. 1981). All the teeth were aged soon after collection. We re-aged all adult teeth ($n = 282$). Any teeth with two different assigned ages were examined again by a third observer.

The annual survival of juvenile and of adult Arctic Foxes were calculated from the age structure (Chapman and Robson 1960). The condition of juvenile and adult Arctic Foxes were compared using a Z-test and Chi-square test (Mendenhall et al. 1981). The proportion of males to females for each age class in the population was examined using a Chi-square test for goodness of fit to a 1:1 sex ratio. The age composition of males was compared to that of females, using a Z-test. Differences in condition between males and females were also examined using a contingency table (Mendenhall et al. 1981). All tests were performed at a 0.05 level of significance. All Chi-square tests had one degree of freedom.

The Arctic Foxes were generally classified as either "coastal" or "inland", depending on the trapline from which they were taken (Figure 1). Traplines 8, 9, and 21 were classified as coastal, since they lie along the west coast of Banks Island, from Sachs Harbour to the Bernard River region (Figure 1), while trapline 10 was classified as inland. The inland and coastal groups were also compared statistically for all years except 1976-77, when no foxes were collected from the inland area. Foxes that could not be classified as coastal or inland ($n = 18$) were not included in these comparisons.

The size of the annual harvest of Arctic Foxes at Sachs Harbour from 1970-71 through 1979-80 was determined from the fur export records of the Northwest Territories Wildlife Service (Dome Petroleum 1982). Although it is generally presumed (Usher 1971b) that the population of Arctic Foxes on Banks Island fluctuates in response to changes in numbers of lemmings, no data on the latter are available. Because numbers and productivity of Ringed and Bearded Seals fluctuated markedly during the period of the study, estimates of their relative abundance, based on Smith and Stirling (1978) and Stirling et al. (1982), were made for the years in which data were available, (1972-73 through 1977-78) so that the possible influence of changes could be evaluated.

Results

Age structure

The age structure of the sample of trapped foxes from 1974-75 was markedly different from that of the subsequent 3 years (Table 1). In particular, young of the year were under-represented, while yearlings were over-represented. The strong yearling cohort of 1974-75 continued to be disproportionately represented through to the end of the study.

There were no consistent differences in the age structure of the coastal versus the inland populations within years (Table 2). A significantly higher proportion of juveniles was trapped inland relative to the coastal region in 1974-75 ($Z = 2.00$, $p < 0.025$) and in 1975-76 ($Z = 2.23$, $p < 0.025$). Of

TABLE 1. Age and sex composition of Arctic Fox samples trapped on Banks Island (1974-75 to 1977-78). * = No foxes were caught in the inland region in 1976-77. M = males; F = females; U = unknown sex; T = total.

Year	1974-75					1975-76					1976-77*					1977-78				
	M	F	U	T	% of total	M	F	U	T	% of total	M	F	U	T	% of total	M	F	U	T	% of total
Age (year)																				
0	5	9	2	16	0.08	39	43	4	86	0.717	29	44	3	76	0.784	73	184	1	258	0.857
1	27	46	5	78	0.39	6	0	0	6	0.05	1	1	3	5	0.052	8	9	0	17	0.057
2	18	21	3	42	0.21	10	6	1	17	0.142	3	1	0	4	0.041	6	8	0	14	0.047
3	7	15	0	22	0.11	5	2	0	7	0.058	7	2	0	9	0.093	2	2	0	4	0.013
4	12	21	1	34	0.17	1	2	0	3	0.025	1	0	0	1	0.01	3	3	1	7	0.023
5	1	3	1	5	0.025	0	1	0	1	0.008	1	0	0	1	0.01	0	0	0	0	0.000
6	2	0	0	2	0.01	0	0	0	0	0.000	1	0	0	1	0.01	0	1	0	1	0.003
7	0	1	0	1	0.005	0	0	0	0	0.000	0	0	0	0	0.000	0	0	0	0	0.000
Total	72	116	12	200		61	54	5	120		43	48	6	97		92	207	2	301	

the 12 Arctic Foxes shot 30 to 65 kilometres offshore from the mainland near Tuktoyaktuk, or out from the west coast of Banks Island, 8 were juveniles and 4 were adults.

Survival

The annual survival of adult Arctic Foxes was calculated for each year (provided the sample size was adequate) from 1974-75 through 1977-78 (Table 3). The survival rate of juveniles was very low for 1975-76, 1976-77, and 1977-78 (7%, 3%, and 7% respectively). In 1974-75, the sample size was too small to facilitate estimation of survival with a catch curve. The survival rates of adult male and female Arctic Foxes for all years pooled were 60% and 58%, respectively (Table 3), while survival rate of juveniles for all years was about half that of adults (29% for males, 20% for females, 23% for both sexes pooled). There were no significant differences between sexes in either age class. Maximum recorded longevity was 6 years for males and 7 years for females.

Survival rates of male and of female juvenile Arctic Foxes, based on pooled samples for the three years compared, was significantly higher for the inland region (male coastal: 0.27, inland: 0.38, $Z = 1.66$, $p < 0.05$; female coastal: 0.11, inland: 0.43, $Z = 5.01$, $p < 0.005$). Survival rates of adults from the coastal and inland areas were not significantly different (male coastal: 0.57, inland: 0.61, $Z = 0.58$, $p > 0.5$; female coastal: 0.65, inland: 0.60, $Z = 0.73$, $p > 0.1$).

Condition

In the pooled samples, significantly more juvenile Arctic Foxes were condition 1 (thin) than were adults (Table 4; $\chi^2 = 4.19$, $p < 0.05$. Within the adult age class, there was no significant difference between males and females in the proportion that were condition 1 ($\chi^2 = 0.077$,

TABLE 2. Age and sex composition of Arctic Fox harvests on Banks Island in coastal and inland regions, 1974-75, 1975-76 and 1977-78. Foxes that could not be classified as inland or coastal were omitted. M = males; F = females; U = unknown sex; T = total.

Year	1974-75								1975-76								1977-78							
	coastal				inland				coastal				inland				coastal				inland			
Age (year)	M	F	U	T	M	F	U	T	M	F	U	T	M	F	U	T	M	F	U	T	M	F	U	T
0	1	1	0	2	3	7	2	12	26	14	4	44	13	29	0	42	39	142	1	182	34	42	0	76
1	11	14	1	26	12	28	4	44	5	0	0	5	1	0	0	1	2	4	0	6	6	5	0	11
2	11	9	1	21	7	10	2	19	9	4	1	14	1	2	0	3	5	8	0	13	1	0	0	1
3	2	3	0	5	5	11	0	16	1	2	0	3	4	0	0	4	2	2	0	4	0	0	0	0
4	5	9	0	14	6	11	0	17	1	1	0	2	0	1	0	1	3	2	0	5	0	0	1	1
5	0	2	0	2	1	1	1	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
6	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
7	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	31	39	2	72	34	68	9	111	42	22	5	69	19	32	0	51	51	159	1	211	41	47	1	89

TABLE 3. Survival rates of adult Arctic Foxes on Banks Island, 1974-75 to 1977-78. Standard deviation is in brackets; n/c = values which could not be calculated.

Year	Adult Survival Rate Male	Female	Both
1974-75	0.605 (0.053)	0.583 (0.038)	0.582 (0.030)
1975-76	0.685 (0.139)	0.913 (0.916)	0.692 (0.093)
1976-77	0.862 (0.138)	n/c	0.806 (0.116)
1977-78	0.437 (0.126)	0.480 (0.093)	0.443 (0.069)
All years pooled	0.601 (0.040)	0.580 (0.033)	0.579 (0.024)

$p > 0.5$). However, significantly more juvenile females were condition 1 than were juvenile males (Table 4; $\chi^2 = 4.87$, $p < 0.025$). There were no significant differences in the proportion of juveniles or adults of each sex classified as condition 1 in the coastal versus the inland sample (Table 4; juvenile male: $Z = 1.41$, $p > 0.05$; female: $Z = 0.29$, $p > 0.10$ adult, both sexes pooled: $\chi^2 = 0.08$, $p > 0.5$).

Sex ratio

The ratios of males to females in the samples were not significantly different from unity for any year except for adults in 1974-75 when there were more females than males ($\chi^2 = 9.03$, $p < 0.005$), and for juveniles in 1977-78 when there were two and one-half times as many females ($\chi^2 = 47.94$, $p < 0.005$) (Table 1).

The ratio of males to females varied in the coastal and inland regions. In 1974-75, the inland region had more females than males ($\chi^2 = 11.33$, $p < 0.005$), while the male to female ratio in the coastal region was not significantly different from unity ($\chi^2 = 0.91$, $p > 0.5$). In 1975-76 and 1977-78, the number of females was not significantly different from the number of males in the inland region (1975-76: $\chi^2 = 2.47$, $p > 0.05$; 1977-78: $\chi^2 = 0.41$, $p > 0.5$). However, in the coastal region, more males than females were trapped in 1975-76 ($\chi^2 = 6.25$, $p < 0.025$) and more females than males were trapped in 1977-78 ($\chi^2 = 55.54$, $p < 0.005$).

Harvest records and Ringed Seal productivity

Figure 2 shows the fluctuations in the number of Arctic Fox furs exported from Banks Island from 1970-71 through 1979-80 and subjective estimates of relative abundance and productivity of Ringed Seals from 1972-73 through 1977-78.

Discussion

Age structure, survival and condition

Except for 1974-75, juvenile Arctic Foxes were by far the most abundant age class (71-86%) in each year's sample. From the large number of foxes trapped in 1973-74 (Figure 2), it is clear that the numbers were very high in that year. The disproportionately strong representation of the 1973-74 cohort throughout the four years of the study (Table 1) also indicates that productivity was exceptionally high in that year. In the following year, 1974-75, the population declined sharply and the production of young was very low (Figure 2, Table 1).

The survival rates of males and females, calculated from the trapped harvest, varied among years for adult Arctic Foxes. Part of the variability probably resulted from small sample sizes but even so, some of the patterns were consistent with observed changes in abandance (Table 3, Figure 2). For example, adult survival rates were lowest in 1974-75 and 1977-78, during and just before two of the years in which there was a marked decline in

TABLE 4. Condition of juvenile and adult Arctic Foxes in coastal and inland areas of Banks Island for the pooled years 1974-75, 1975-76, and 1977-78.

		Coastal condition class:			Inland condition class:			Total condition class:		
		1	2	3	1	2	3	1	2	3
Juvenile	M	42	9	24	33	5	10	75	12	34
	F	99	9	27	50	8	12	149	17	39
Adult	M & F pooled	23	6	12	11	2	8	(M) 23 (F) 11	6 2	12 8

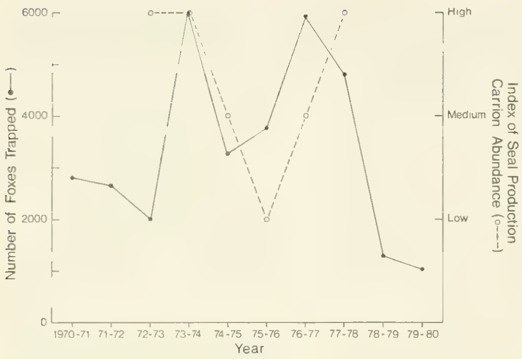

FIGURE 2. Annual trapped harvest of Arctic Foxes from Sachs Harbour (solid line) and relative abundance of seal carrion (dotted line) from 1970-71 to 1979-80. From Dome Petroleum (1982), Smith and Stirling (1978), and Stirling et al. (1982).

trapping returns. In contrast, adult survival rates in 1975-76 and 1976-77 was much higher as the population was entering the two high catch years of 1976-77 and 1977-78. These patterns were shown by both males and females indicating that the changes did not result from sex-specific causes.

Although juvenile survival rates were very low (less than 8%) for all years except 1974-75, the survival rate for all years pooled was 23%. This was probably due to the large yearling cohort from 1974-75, which may have biased the calculation. We believe, however, that 23% is likely to be a reasonable estimate of the juvenile survival rate. Because juvenile Arctic Foxes are less experienced in foraging and more naive than adults, they may be more likely to investigate traps and thus be over-represented relative to adults, especially in years when natural food sources are scarce. If so, annual juvenile survival may be underestimated but we have no way of evaluating this.

Condition of the animals may also affect their representation in the trapped sample. Adult Arctic Foxes were in significantly better condition than juveniles, and thus might be less likely to turn to trap bait as a food source. Hence, adults may have been underrepresented in the trapped population.

Sex ratios of the harvests

The 1:1 male to female sex ratio is consistent with that found by Macpherson (1969) and Hammill (1983). There were no consistent patterns in the ratio of juvenile males to females between years.

The sex composition of the coastal and inland samples varied widely between years, but not in any consistent pattern. Some of this variability undoubtedly results from relatively small sample sizes in some years. In addition, animals of both sexes probably travelled and mixed, thus obscuring any possible trends.

Comparison of foxes caught inland and along the coast

The trapped samples from the coastal and inland areas had similar proportions of juvenile and adult foxes (Table 2). Theoretically, adults might be expected to be more abundant inland, remaining in their breeding territories, feeding on lemmings and forcing the juveniles out (Macpherson 1969), thereby stimulating movement of the juveniles to the coast (Chesemore 1967) or to areas unoccupied by adult Arctic Foxes. Banks Island trappers ". . . believe there is a basic seasonal movement as follows: after freeze-up, some foxes begin to move off the land and on to the sea ice, where they spend most of the winter. In late winter, these foxes return to the land again to begin the breeding cycle. Reports of "runs" are most frequent before Christmas, when the trappers say the foxes (at least on south central Banks Island) move north and west, and during the last month of the season, when foxes begin to move inland. Blubber stained foxes have been trapped over 60 miles from the nearest coast, chiefly in spring." (Usher 1971b; p. 10). Similar seasonal movements have been reported from the Alaskan Arctic slope, Baffin Island, the Hudson Bay and James Bay regions, and northern Manitoba (Chesemore 1968a; Chitty and Chitty 1945; Wrigley and Hatch 1976). However, Eberhardt et al. (1983) found that some juveniles stay in their natal home range until mid-January. As well, territoriality in Arctic Foxes appears to be less strong in fall and winter than in spring and summer (Eberhardt et al. 1982). Thus, in Alaska at least, juveniles may not move to the coast in the same way as has been suggested to occur on Banks Island. Unfortunately, our data were too few to analyze by season.

The winter diet of the Arctic Fox on Banks Island depends on its habitat. Arctic Foxes on the sea ice mainly scavenge the remains of marine mammals, whereas on land they feed mainly on lemmings and scavenge opportunistically on Caribou, Arctic Hare (*Lepus arcticus*), and ptarmigan (*Lagopus* spp.). On Banks Island, there were no significant differences in condition between the coastal and inland samples, suggesting that Arctic Foxes of all ages and from all areas travel and mix extensively, or that food availability in both areas was similar.

Population changes

There are several factors that could influence the survival, and consequently the age structure and abundance of Arctic Foxes trapped. The availability of terrestrial prey species, principally lemmings, is the most important factor determining the size and productivity of Arctic Foxes in other areas (Chesemore 1968b; Macpherson 1969; Speller 1972). Usher (1971a) reported that the number of Arctic Foxes trapped on Banks Island each year from 1928 through 1967 was characterized by fluctuations in numbers at approximately four-year intervals, suggesting a strong dependence on lemmings as the basic food source there as well.

In the summer of 1974, numbers of lemmings on Banks Island were apparently low and many Arctic Fox dens were not occupied (BEAK Consultants 1975). If so, production and survival of pups were probably low as well, partially explaining the reduced representation of juveniles in the 1974-75 winter trapping season. Unfortunately, there are no data, or even subjective impressions, on relative abundance of lemmings on Banks Island in any other years.

It is well known that Arctic Foxes move onto the sea ice during the winter to scavenge on seal carrion, and to prey upon Ringed Seal pups, but the overall significance of this resource to the maintenance of the Arctic Fox population in the Western Arctic is not understood. In the eastern Beaufort Sea, Smith (1976) and Stirling and Smith (1977) suggested that Ringed Seals could form a significant supplemental food source. During Polar Bear population studies conducted up to 160 km offshore, Arctic Foxes and their tracks were seen wherever seals were killed by bears. Inuit trappers often comment on how commonly the fur of trapped Arctic Foxes is oiled from feeding on seal carcasses. Of the 12 Arctic Foxes shot on the sea ice, eight were juveniles, which is similar to their proportion in the trapped sample, indicating that animals of all ages use this habitat. The availability of a high energy alternate food source on the sea ice in areas such as the eastern Beaufort Sea may help sustain higher populations of Arctic Foxes through the winter than might be possible in places such as the barrengrounds where no such option is available. This could be of particular importance to the more subordinate and less experienced juveniles.

As noted earlier, the fact that the peaks in the numbers of Arctic Foxes harvested on Banks Island occur at about four-year intervals (Usher 1971a) strongly suggests that the availability of lemmings in the spring and summer is the main factor determining productivity and survival of young foxes there. However, during the 1970s, even in "poor" years, the harvest levels were usually well over 1000 (Dome Petroleum 1982) which is still quite substantial, especially when compared even to the average harvests in many other settlements in the Northwest Territories (Smith and Taylor 1977). This suggests that in years when food availability on land (principally lemmings) is low, the Arctic Fox population on Banks Island still has access to a large and nutritious food supply (seal carrion) with which to survive the winter in good health. If lemming numbers remain low, as appears to have been the case in 1974, fewer females would be in good enough condition to reproduce and more would divert scarce resources to their own survival. Since adult Arctic Foxes may live several years, they could endure a year or two of low numbers of lemmings by using seal carrion during the winter. When lemming numbers increase again, female productivity and survival of young respond accordingly. This alternative food resource probably facilitates the survival of a much larger core population of adult Arctic Foxes than might otherwise be the case and would lead to the production of more young, as is reflected in the consistently high numbers of animals trapped each year on Banks Island. It is also likely that emigration of juvenile foxes from Banks Island is responsible for a significant amount of the harvest at other Beaufort Sea coastal settlements such as Holman and Tuktoyaktuk.

The high harvest levels of Arctic Foxes in 1973-74, 1976-77, and 1977-78 all occurred in years when the numbers and productivity of seals were moderate to high during the spring (Figure 2) (Stirling et al. 1982); thus, the availability of seal carrion from Polar Bear kills likely also remained high through the winter (Stirling et al. 1977). The availability of young seals was low in the winter of 1974-75 and probably even lower in 1975-76 (Smith and Stirling 1978). The Arctic Fox harvest dropped by almost 50% in 1974-75 from the previous year and, although it increased slightly in 1975-76, it remained at a similar level (Figure 2). Consequently, while there is a correlation between seal productivity and the number of Arctic Foxes trapped, a clear cause and effect relationship cannot be established at this time. Carrion from the large populations of terrestrial species such as Caribou and Muskoxen (*Ovibus moschatus*) and ground-nesting waterfowl such as Snow Geese (*Anser caerulescens*) may also be important in some years.

Implications for further study

The results of this study raise some related questions about the population dynamics and food habits of the Arctic Fox on Banks Island. Fluctuations in Arctic Fox numbers are strongly influenced by the abundance of lemmings but other food sources also play an important role. Both juvenile and adult Arctic Foxes appear to use seal carion left by Polar Bears as food, and there appears to be a relationship between the size of the

Arctic Fox harvest and the abundance of seals during the previous year. The amount of seal carrion could also be influenced by the size of the Polar Bear population. There are other related observations, the significance of which is not clear. For example, in 1974 when food availability appears to have been low on Banks Island, 21 Arctic Foxes were tagged. Four of them were recovered, in 1975, 20-300 km from where they were captured and one had moved over 1500 km (R.D. Hennig, Beak Consultants, personal communication; Wrigley and Hatch 1976). Similar movements have been recorded for Arctic Foxes in Manitoba, Newfoundland, and northern Alaska (Wrigley and Hatch 1976; Chesemore 1968a; Eberhardt and Hanson 1978; Northcott 1975). Clearly, patterns of seasonal migration, reproduction, survival, and dispersal of Arctic Foxes on Banks Island should be investigated in relation to the abundance of prey and carrion.

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Seaward Migration of Juveniles of Three Herring Species, *Alosa*, from an Estuary in the Annapolis River, Nova Scotia

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The downstream migrating populations of juvenile American Shad (*Alosa sapidissima*), Alewife (*Alosa pseudoharengus*), and Blueback Herring (*Alosa aestivalis*) were studied in the Annapolis River, Nova Scotia during the autumn of 1985 and 1986. Downstream migration of alosines occurred in September and the fish moved to the sea through the Annapolis Barrage in October. The daily period of onshore movement in the estuary was between 1800 and 2300 hours. Environmental factors associated with increased downstream migration were: increased precipitation, a rapid decrease in water temperature and moon phase (new).

Key Words: American Shad, *Alosa sapidissima*, Alewife, *Alosa pseudoharengus*, Blueback Herring, *Alosa aestivalis*, downstream migration, Annapolis River, Nova Scotia.

The particular combination of extrinsic factors that triggers the seaward migration of juvenile alosines from estuaries is uncertain. Studies concerning the riverine phase of the life cycle suggest that increased river flow, decreasing water temperature or a combination of both during autumn are key factors (Sykes and Lehman 1957; Walburg and Nichols 1967; Moss 1970). In the Connecticut River, however, O'Leary and Kynard (1986) concluded that decreased temperature, occurring during a new or quarter moon, was the major stimulus, rather than increased river flow. Loesch et al. (1982) also found that light levels played a major role in the daily behaviour of alosines.

During the fall seasons of 1985 and 1986, we examined the seaward migration of juvenile alosines through the estuarine headpond and turbines of the Annapolis Royal Tidal Power Station. The alosine population was classified and seaward migration patterns were compared to climatic and environmental parameters in an attempt to discover the major cues for migration.

Site Description

The Annapolis River and estuary (44°40′ N, 60°40′ W) are located at the head of the Annapolis Basin, on the Bay of Fundy, Nova Scotia (Figure 1). In 1960 a tidal dam was constructed across the estuary at the town of Annapolis Royal. The dam creates a tidal headpond of 10.8×10^6 m^2 at geodetic datum (sea level) (Melvin et al. 1985). During 1985 a hydroelectric tidal generating plant became operational in the causeway (Dadswell et al. 1986). The head-pond is now a well-mixed estuary with a 2 m tidal range and surface salinites in autumn of 25-30‰. Seaward migration of fishes is possible through the turbine or one of the two fishways (Figure 1).

Three species of alosines spawn during the spring in the Annapolis River between Bridgetown and Middleton (approximately 20 to 40 km upstream from the tidal power dam): American Shad (*Alosa sapidissima*), Alewife (*A. pseudoharengus*) and Blueback Herring (*A. aestivalis*), (Daborn et al. 1979). Juveniles of the clupeids Atlantic Herring (*Clupea hargengus harengus*) and Menhaden (*Brevoortia tyrannus*) also utilize the estuary.

Methods and Materials

Shore Seining

Three shore seine sampling sites were located in the estuary above the causeway (Figure 1). Sampling was conducted in August, September and October in both 1985 and 1986. Sites had hard bottom substrata of mud, sand or gravel and were selected primarily for ease of seining. We used a 30 x 2 m shore seine with 1 cm stretch mesh wings and 0.5 cm stretch mesh bag. The seine was set by boat in a u-shaped fashion, with the bag at a depth of 1.5 m. Hauling provided a semi-quantitative sample from an area of 100 m^2. Fish were sorted, identified to species, measured and either released or preserved for later species verification. On 27, 28, 29 August 1985, seine collections were taken at site 1 at 2-hour intervals for 24 hours to determine the optimal fishing period (based on maximum catches) for alosines during the diurnal cycle. Further sampling was conducted at 1/2 hour intervals during the determined optimum fishing period thereafter. Seine catches from all three sites were combined to obtain mean weekly catch for the estuary.

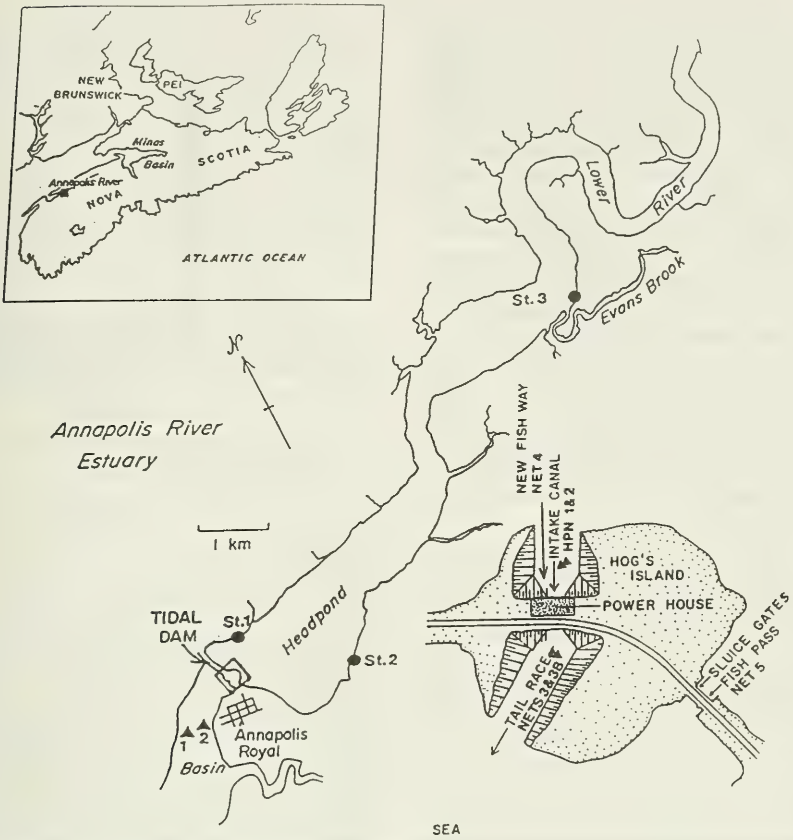

FIGURE 1. The Annapolis River estuary and causeway indicating seine and plankton net sampling sites.

Turbine Draft Tube and Fishway Sampling

Sampling at the turbine and fishways was conducted with plankton nets of 1 m diameter, 6 m in length with a mesh opening of 0.35 mm. Two nets (HPN1 and HPN2) were placed at the upstream entrance of the draft tube (Figure 1) for 10 nights to determine the depth at which fish were entering the turbine. The draft tube entrance is approximately 2 m under the headpond's low water level. Two nets (3 and 3B) were set in the turbine tailrace 25 m downstream from the draft tube and maintained in the top meter of the water column by an attached buoy. On two occasions a pair of nets were set on bottom at this site to determine the relative proportion of fish in the bottom strata (8-10 m). In 1985, one net was deployed in each fishway (4 and 5; Figure 1) during the same period as the tailrace monitoring. Fishway nets were maintained with the upper portion of the net ring at 1 m in depth. On a nightly basis fishway nets were exchanged with tailrace nets to test for catchability bias between nets. During 1985 tailrace sampling was conducted during daylight and nocturnal generation periods. Based on 1985 findings, tailrace sampling in 1986 was conducted only during night generation periods.

During 1985 fishing at the causeway was from the period 1 September to 30 October and during 1986 from 6 August to 14 November. Fishway and tailrace nets were set just after generation commencement and lifted just before generation stopped. All captured fishes were identified to species and clupeids measured.

Hydrographic and environmental parameters monitored during the study period were: river flow (m^3/sec) obtained from Tidal Power Corporation records at their Lawrencetown station; precipitation (mm/day) from the Greenwood weather station; Site 1 and Site 3 daily surface water temperature (C°) using a mercury thermometer; and weekly surface salinity at sites 1 and 3 using a YSI salinometer. Lunar phase was determined from the Canadian tide and current tables (1985, 1986. Department of Fisheries and Oceans Canada: Atlantic Coast and Bay of Fundy 1: 50 pages).

Results

Seine Survey

During 1985, a total of 224 seine hauls was completed between 27 August and 19 October. During 1986 a total of 130 seine hauls was made between 1 August and 3 November. The majority of the 1986 hauls (122) were at Site 3. Twenty-nine species of fish were collected (Stokesbury 1987) and a total of 2564 alosines were captured (Table 1). Catches in 1985 were dominated by Blueback Herring (70%). During 1986, American Shad was the most abundant alosine (56%) but total catch was much lower than in 1985. Both Atlantic Herring and Menhaden were more abundant in 1986 (Table 1).

The 24-hour sampling experiment from 27-29 August indicated the optimal sampling period for alosines was sunset to 0100 (Figure 2). Therefore standardized sampling was taken during this period.

Catches at site 3 on 17 September 1985 characterize the general observed pattern of capture. Samples collected at 1/2 hour intervals commenced at 1845 and ended at 2325. Sunset was at 1900 hours. Maximum catches occurred at twilight between 1920 and 1955 hours (Figure 3).

Mean seine catch/week in the estuary peaked during mid-September in 1985 and mid-August in 1986 (Figure 4). Late start of sampling during 1985, however, may have caused us to miss an earlier peak of abundance. During 1986, few juvenile alosines were captured at seine sites after 11 October. This was two weeks earlier than in 1985, when the major decline in catch did not occur until late September and alosines were collected as late as 19 October.

Mean size of each of the species of captured young-of-the-year (YOY) alosines was greater in 1985 than in 1986 (Table 2). Juveniles living in the estuary during October in 1986 were all significantly (0.05) smaller than those emigrating during 1985 (t-test, 2.90/range 1.96). Growth rates determined during 1986 were also much less than those observed during 1985 (Table 2). Lower growth rates found during 1986 may have been due to the cooler temperatures. Mean temperature during September 1985 was 4°C warmer (18°C) than during September 1986 (14°C).

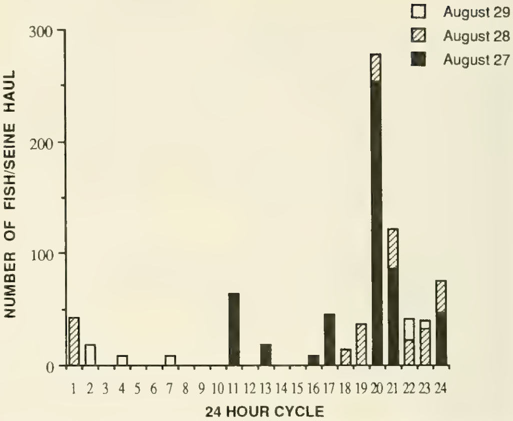

FIGURE 2. Total species captured in relation to time of day at Station 1, 1985.

Turbine Catches

Seaward migration of alosines was monitored at the turbine site on 20 nights in 1985 and 28 nights in 1986 (Table 1). Effort was 108 net nights in 1985 and 148 net-nights in 1986. A total of 1282 alosines were captured in 1985 but only 84 in 1986 (Table 1). Blueback Herring was the most abundant species in both years (68% and 55% of total). Atlantic Herring was very abundant during 1986 (89% of clupeids).

Nets set in the turbine intake indicate the majority of alosines were approaching the turbine

TABLE 1. Clupeids captured by seining and in causeway nets in the Annapolis estuary 1985 and 1986.

		Number Captured			
		Seine		Causeway	
Species		1985	1986	1985	1986
Alosa sapidissima		306	123	128	32
Alosa pseudoharengus		387	18	275	6
Alosa aestivalis		1644	86	879	46
Clupea harengus		148	1004	91	994
Brevoortia tyrannus		0	43	4	42
Sein	Hauls	224	130		
	Days	35	27		
Plankton nets	Hauls			108	148
	Days			20	28

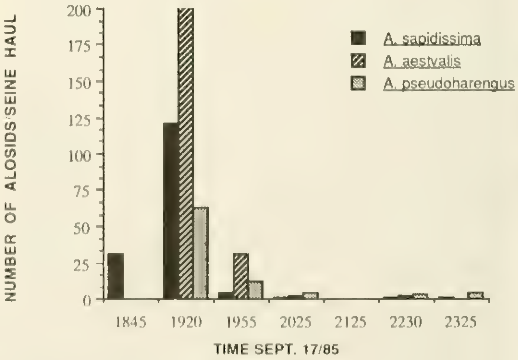

FIGURE 3. Catch of alosines at Station 3, 17 September 1985, in relation to time.

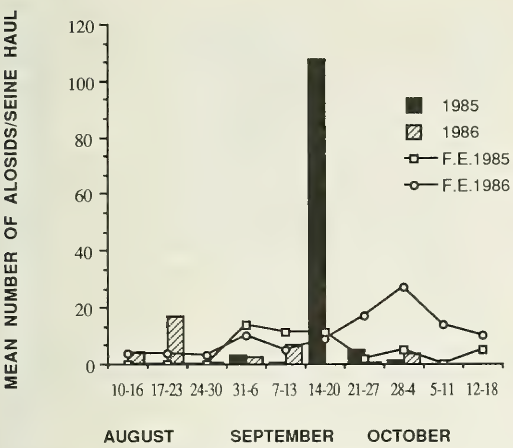

FIGURE 4. Mean weekly seine catches in relation to effort at all sites in the Annapolis River estuary during 1985 and 1986.

at depth (Table 3). Catches of Atlantic Herring were similar at surface and depth. In the tailrace, however, catches of alosines were greatest at the surface.

Comparison fishing between the turbine tailrace and the two fishways indicated the majority of the alosines emigrated seaward through the turbine (1282 v.s. 17 in 1985). As a result of these findings we monitored only the tailrace during 1986. Similarly, the alosines emigrated at night. In day/night comparison fishing during 1985, 97% of the fish catch was made during the night (Figure 5).

Catches in the turbine tailrace nets were greatest in both 1985 and 1986 during October (Figure 6 and 7). In 1985, no alosines were captured before 30 September and the majority were captured in a 10-day period (15-25 October). A second small peak of emigration occurred between 28-25 October. During 1986, however, alosines emigrated seaward between mid-August and mid-November. A slight peaking of emigration occurred during the new moon periods in early October.

Environmental characteristics during the two years were dissimilar (Figure 6 and 7). The autumn of 1985 was warm and dry. Estuary temperatures did not decline until mid-October at the same time freshwater input increased. The new moon occurred on 13 October 1985. The autumn of 1986 was cool and wet. Temperatures declined steadily with a very sharp drop in the first week of October. River input increased to double the 1985 levels in mid-September and remained at levels higher than those in 1985 until the end of observations. The new moon occurred on 1 September and 1 October 1986. An analysis of variance indicated alosine emigration events were not related to environmental parameters in 1985 or 1986, possibly because of the small data base for both years (ANOVA, $p > 0.05$).

Mean length at emigration during 1986 was less for all species than during 1985 (Table 2). American Shad and Blueback Herring were approximately 30 mm and 40 mm smaller when they passed the turbine. Alewives maintained a better growth rate in 1986; length averaged 20 mm less than in 1985.

Using a population estimate based on the proportion of tailrace sampled by our nets in relation to depth (Stokesbury 1987), we estimate 115 000 YOY alosines passed seaward through the turbine in 1985 but only 18 000 during 1986. Reduced estimates of emigration during 1986 agree with the lower seine catches in that year and cannot be related to sampling intensity, which was greater.

Discussion

Light intensity is known to have a marked effect on the catchability of alosines, both juveniles and

TABLE 2. Mean size and growth rate of young-of-the-year (YOY) alosines captured during 1985 and 1986 in the Annapolis River estuary at inland (seine) and seaward (turbine) sites. The mean day of capture based on large sample sizes was 17 September 1985 and 25 August 1986 for inland sites and 20 October 1985 and 8 October 1986 for the turbine site. (FL), fork length ± (SD), standard deviation.

Species	Year	Shore seine (mm)	Turbine (mm)	Days at large	Growth mm/day
A. sapidissima	1985	64.9 ± 7.1	90.4 ± 9.1	33	0.77
	1986	58.1 ± 6.6	61.7 ± 6.8	44	0.08
A. aestivalis	1985	67.5 ± 13.9	101.2 ± 11.5	33	1.02
	1986	61.1 ± 10.5	67.9 ± 9.2	44	0.15
A. pseudoharengus	1985	88.3 ± 17.4	113.6 ± 19.3	33	0.77
	1986	74.8 ± 18.5	90.7 ± 9.7	44	0.36

TABLE 3. Number of alosines and/or clupeids captured in nets at the surface and at depth in front of the turbine and in the tailrace.

		Effort	Fishes Captured	
Net Position		net-nights	*Alosa*	*Clupea*
Turbine Intake	(0-3 m)	20	1	46
	(8-10 m)	20	9	54
Tail race	(0-2 m)	4	133	-
	(8-10 m)	4	5	-

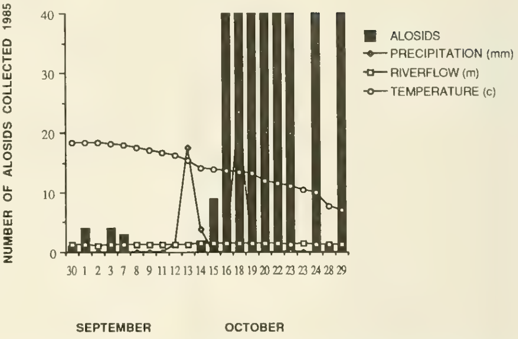

FIGURE 6. Catch of alosines by turbine tailrace plankton nets during 1985 in relation to selected environmental parameters. Note: maximum fish catch is not shown.

adults (Loesch et al. 1982; Dadswell et al. 1983). Juvenile alosines utilize the Annapolis River estuary as a nursery area from August to October but schools apparently remain offshore and catchability with seines is low except during twilight and early evening. Onshore movement was rapid and short-lived and sizable catches apparently depended on encountering a school. O'Leary and Kynard (1986) observed similar behaviour among YOY American Shad during their downstream migration in the Connecticut River.

Seaward migration in estuaries seems to be a rather slow process for alosines. The weekly catch rate of alosines at inland estuarine seine sites declined from high levels in late summer and early fall but few were encountered at the seaward terminus of the estuary until October. Since catches of YOY alosines are known to vary dramatically due to schooling (O'Leary and Kynard 1986), the virtual absence of alosines from the inshore regions of the Annapolis estuary for almost a month before a final seaward migration suggests they school offshore in the estuary until the correct migration stimulus occurs.

Seaward migration during 1986 was two weeks earlier than during 1985 but both peak emigration events occurred during new to quarter moon periods (dark nights). Coincident with the dark nights was a sharp decline in water temperature below 12° C. River input to the estuary during 1986 was almost twice the 1985 levels but appeared to play little role in stimulating seaward

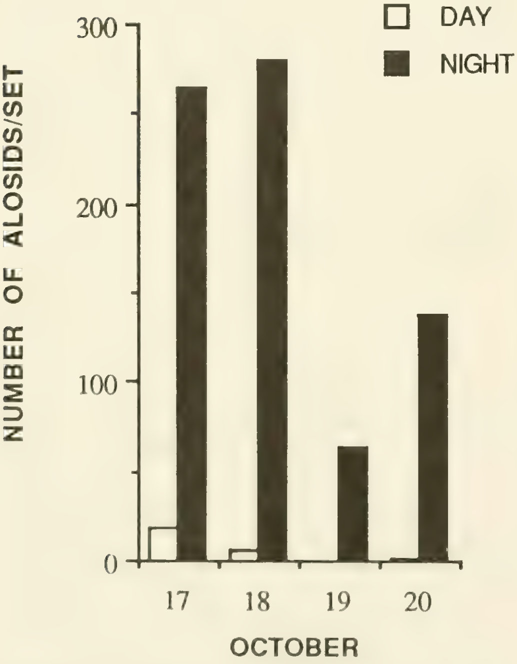

FIGURE 5. Capture of alosines by turbine tailrace plankton nets in relation to daylight and dark fishing period, 17-20 October 1985.

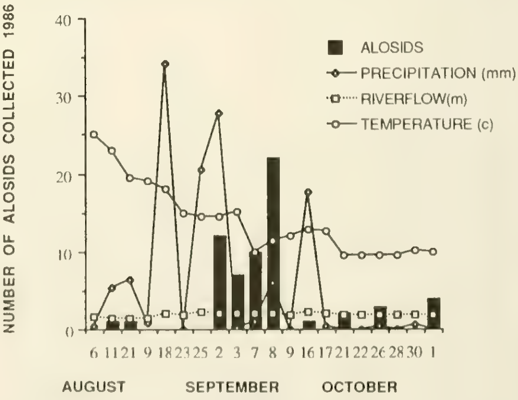

FIGURE 7. Catch of alosines by turbine tailrace nets during 1986 in relation to selected environmental parameters.

movement. Decreasing water temperature and the new moon period rather than river flow have been shown to be most important under riverine conditions (Marcy 1976; O'Leary and Kynard 1986).

On a 24-hour basis, seaward movement of alosines was predominantly at night. The documented negative phototrophic response of alosines appears to keep them relatively immobile during daylight hours (Loesch et al. 1982).

Size at emigration appears to be important among salmonids (Randall et al. 1987) but may not be a critical factor for alosines. Both American Shad and Blueback Herring were 30% smaller in 1986 than in 1985 when they migrated out of the Annapolis estuary. Perhaps environmental stress reached a point where seaward movement was necessary regardless of a critical size. Whether or not this affects later survival is unknown.

Overall lower seine catch rates during 1986 may have been simply a result of low abundance that year. Cool estuary temperatures had a marked effect on 1986 growth rates and may have been a factor in the estimated 90% reduction in the 1986 alosine year-class size compared to the 1985 YOY population. Cool, wet summers were demonstrated to be a factor in the year class success of shad in the Connecticut River (Crecco and Savoy 1984). Mansfield and Jude (1986) state that major decreases in year class strength during one season is common and that alosine populations have the ability to recover from catastropic mortality in one or two years. However, it is not known if they have the ability to withstand a large annual increase in mortality.

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Notes

Decline of the Kent Island, New Brunswick, Herring Gull, *Larus argentatus*, Colony

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Hébert, Percy N. 1989. Decline of the Kent Island, New Brunswick, Herring Gull, *Larus argentatus*, colony. Canadian Field-Naturalist 103(3): 394–396.

During a study of the reproductive ecology of the Herring Gull, *Larus argentatus*, on Kent Island, New Brunswick, I undertook a census of the island in late June 1984 to determine the size of the colony. I estimated a total of 1441 pairs to be nesting on the island, down from an estimated 5000 pairs in 1980. The cause of this decline may be persistent removal of eggs by local people.

Key Words: Herring Gull, *Larus argentatus*, Kent Island, decline.

After doubling in size every 12 to 15 years since the turn of the century (Kadlec and Drury 1968), the western North Atlantic Herring Gull, *Larus argentatus*, population stabilized and even declined in some areas (Drury and Nisbet 1973). Drury and Nisbet (1973) hypothesized that this change might be due to a southward shift in the centre of population growth.

Kent Island, New Brunswick, (44°35′N; 66°45′W) once supported a Herring Gull population estimated at 25 000 pairs (*see* Cannell and Maddox 1983). The colony subsequently declined, especially between 1950 and 1965, and then stabilized at 5000 to 8000 pairs (Cannell and Maddox 1983).

I conducted a census on 21 June 1984 on the southern two-thirds of the island not occupied by trees (*see* Paynter 1949; Figure 1). To avoid counting nests twice I sprayed paint on an area adjacent to the nest. I counted only active nests, that is, nests containing at least one egg or chick. The location of nests was recorded and classified into three groups: 1) rock (nest built on rock or pebbles), 2) raspberry (*Rubus idaeus*; nest built in raspberry), and 3) meadow (50% or less raspberry).

I found 1341 nests in the area surveyed (Figure 1). Of these, 28.2% were found on the shore and rock ledges, 24.7% in raspberry, and 47.1% in grassy and meadow areas. Approximately 1200 of these nests were located in the main gull colony at the southern one-quarter of the island. A similar survey in 1987, of approximately the same area, found 1300+ nests (Lee 1988). An additional 100 nests may be added as an estimate of the number of nests outside the census area (estimated from casual observations made earlier in the breeding season). In the latter part of May and early June an estimated 200 nests were destroyed by humans. It is possible, however, that these nests were replaced prior to the census, and hence it is assumed that they are included in the census of nests. Therefore, it is estimated that a total of 1441 pairs nested on Kent Island during the summer of 1984.

Hatching success was low in both two-egg (0.95 eggs/clutch; n = 102) and three-egg nests (1.73 eggs/clutch; n = 49) (Hébert and Barclay 1988) compared to previous (Paynter 1949; Knudsen 1987) and subsequent (Lee 1988) studies. This is primarily due to egg loss resulting from cannibalism by other gulls and possibly removal of eggs by humans.

Of a sample of 141 two-egg and 94 three-egg clutches, 20.2% and 9.2%, respectively, lost one egg within five days of being laid (Hébert and Barclay 1988). Growth rates (Hébert 1985; Hébert and Barclay 1988) of Herring Gull chicks in 1984 were also similar to or lower than those observed at Kent Island in previous (Knudsen 1987) and subsequent years (Lee 1988). Fledging success in 1984 was extremely low in both two (0.21 chicks/nest) and three-chick (0.33/nest) broods (Hébert and Barclay 1988). This is in part due to an unusually long period of fog (R. Cunningham, personal communication), which occurred during peak hatching and affected food availability and chick survival (Hébert 1987).

Vegetational succession may also affect the size of larid colonies (Courtney and Blokpoel 1983). However, since all suitable open nesting sites were not occupied by the gulls, and gulls were found

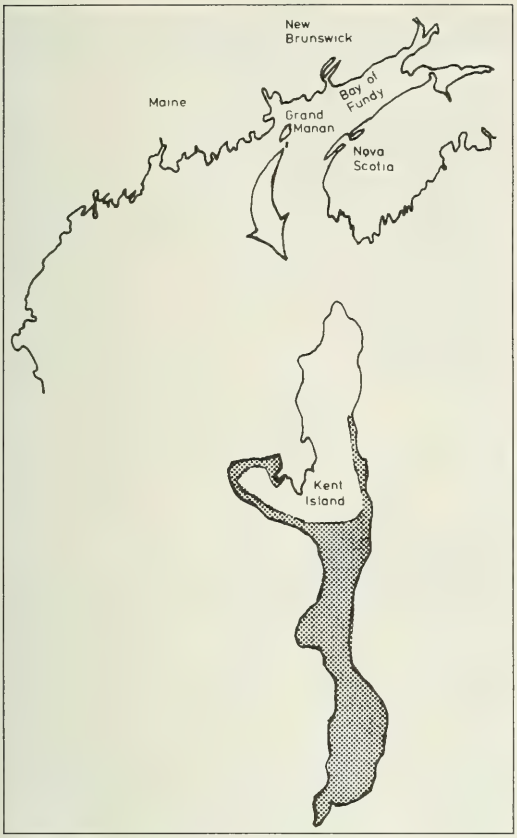

FIGURE 1. Map of Kent Island, Bay of Fundy, New Brunswick. Stippling indicates areas covered by the census.

nesting in raspberry, vegetational succession does not seem likely to have caused a decline of this magnitude.

Human predation has occurred for many years (C. Huntington, personal communication). During the last two weekends in May and the first two weekends in June, between 4 and 20 "eggers" visited the colony. Although my presence reduced their area of activity, their actions appeared to have significantly affected the gulls.

The eggers arrived at approximately 1300 h, and in some cases did not depart until 1800 h. While in the colony the "eggers" travelled in loose groups, often displacing approximately 50 gulls at a time. Complete as well as partial clutches were removed. The actual number of eggs taken on any one visit was not quantified directly, but each visitor carried either a one-gallon or a five-gallon pail. Thus, a rough estimate of the total number of eggs taken during a single day would be between 50 and 100 eggs. Some "eggers" were also observed destroying eggs indiscriminately.

Such disturbances likely influenced reproductive success (through cannibalism and abandonment). The removal of complete or partial clutches released pairs from incubation or brooding duties, and hence temporarily increased the number of potential cannibals in the colony (*see* Paynter 1949; personal observation). Kadlec and Drury (1968) found that the degree to which reproductive success was adversely affected was directly proportional to the proportion of the colony disturbed and the duration of the disturbance. Such large-scale disturbances have been postulated as the cause of colony desertions elsewhere (Buckley and Buckley 1977 *in* Erwin et al. 1981).

The decline of the colony may at least be in part, therefore, due to "egging" by local residents. The "egging" is for the most part not of a subsistence nature, and is contrary to the Migratory Birds Convention and Act.

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Breeding Blackpoll Warblers, *Dendroica striata*, in Duck Mountain Provincial Park, Manitoba

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In 1986, two male Blackpoll Warblers (*Dendroica striata*) were identified at the height of the breeding season in and by a Black Spruce (*Picea mariana*) bog in Duck Mountain Provincial Park, Manitoba. In 1987, at least seven adult Blackpolls including one pair were located in the same area. Three young just flying or incapable of flight were seen on 7 and 8 July. One was caught by hand and photographed. This documents this species as breeding 240 km south of its previously known limit, The Pas, Manitoba.

Key Words: Blackpoll Warbler, *Dendroica striata*, food-carrying, juvenile, Duck Mountain Park, photograph, Manitoba.

In Manitoba, the Blackpoll Warbler (*Dendroica striata*) breeds north of 54°00′ which includes the area north of the Saskatchewan River at The Pas and Lake Winnipeg (Godfrey 1986). Although L'Arrivée and Guinan (1979) noted a male singing on its territory during a census transect in Duck Mountain Provincial Park 1 km W of Provincial Road 367 along a trail to Trapper Lake, 51°35′N, 100°57′W, they had no confirmation of successful breeding. This account and photograph (*see* front cover) document the Blackpoll Warbler as a breeding species in Duck Mountain Provincial Park, Manitoba.

Parker Bog (51°48′N; 100° 54′W) is situated 0.25 km south of Wellman Lake in the northern sector of Duck Mountain Provincial Park in central western Manitoba. Although ecologically similar to more northerly spruce bogs, Parker Bog is 240 km south of the Blackpoll Warbler's known breeding range in northern Manitoba. This bog is a 2.5 ha (6.2 acre) open water area (OWA) surrounded by Black Spruce (*Picea mariana*) forest of moderate height which extends a few hundred meters from SE to W of the OWA. Immediately to the E and N of the bog, a right-of-way clearing, now well-vegetated with shrubs, was made on higher terrain several years ago in preparation for the relocation of Provincial Road (PR) 366 within 50 m of the NE corner of the OWA. Beyond the right-of-way to the E on yet higher ground, a small stand of fairly short White Spruce (*Picea glauca*) and Balsam Fir (*Abies balsamea*), "The Hill", is situated 250 m E of the OWA and about 20 m W of the Wellman Lake store. Early second-growth White Spruce, Trembling Aspen (*Populus tremuloides*) and Jack Pine (*Pinus banksiana*) 2-4 m tall dominates the vegetation above the bog to the NW of the OWA. Parker Bog lies 715 m A.S.L. (above sea level) and 415 m above the aspen parkland below the Duck Mountain plateau.

I visited Parker Bog on 28 June 1986 with two other observers and located a singing male Blackpoll Warbler 30m S of the OWA in stunted Black Spruce-*Sphagnum* sp. moss habitat. This was the first summer (breeding season) record in southern Manitoba for all three observers. A second male sang in "The Hill" habitat and twice was seen leaving its perch to chase small birds.

On 4 July 1987, a singing male Blackpoll Warbler was again located on "The Hill". In the bog, a singing male and a nervous food (moth)-carrying female were found 80m S of the OWA. While the male sang and periodically investigated the human intrusion, the female flitted short distances from tree to tree in a somewhat denser area of the Black Spruce bog — the DBS area giving "chick" alarm notes. During a 30 min. observation, the female maintained her vigil and was rarely out of sight for more than a few seconds, sometimes coming within 4 m of me. The moth disappeared after the first 10 minutes. Efforts to find the nest were unsuccessful.

When first encountered, the female was joined briefly by a Palm Warbler (*D. palmarum*), some 160 km S and W of its known breeding range in Manitoba (Godfrey 1986). It subsequently sang in the vicinity. Four more singing Blackpoll Warblers were identified along 0.7 km on the S side of the existing PR 366 in the early second-growth habitat NW of the bog.

Food-carrying adults were again found in the DBS area on 7 July, but in 2 h of observation and searching, no active nest was located. Some 40-50 m N of the DBS area excited "Tit-tit-tit" notes of young birds being fed were heard as I moved toward the OWA. In a few seconds, a food-carrying female Blackpoll Warbler nervously flitted about between the stunted spruce and Tamarack (*Larix laricina*), then flew 8-10 m directly E and fed a juvenile Blackpoll Warbler perched low in a small Black Spruce. Coincidently a male Blackpoll Warbler sang just to the west. An attempt was made to photograph this fledgling, but it fluttered down to the Sphagnum and disappeared. About a minute later, this or another fledgling, tended by the female Blackpoll Warbler, flew 8-10m across an open area and out of sight into the spruces. As I left the bog via the DBS area a male Blackpoll Warbler sang nearby, suggesting that the encounter involving the Blackpoll Warblers 40-50m N of the DBS area may have been a different family.

A male Blackpoll Warbler was carrying food and giving "chick" alarm notes on the W side of the DBS area when the bog was visited on 8 July. The bird came unusually close to me and less than 1 m from the *Sphagnum* sp. Suddenly a tiny, chirping juvenile scampered with difficulty through the vegetation toward the male. This juvenile, incapable of flight, was identical to the one seen the previous day — the two white wing bars being prominent traits of both. It was easily caught and photographed in the hand. When held, the bird chirped and squawked loudly, drawing both alarmed food-carrying adults close. When the bird was placed under the author's cap on his head — to free both hands for photographing the adults — it was much quieter causing the parental birds to stay too far away for photographs. When nearby potential avian predators, Bonaparte's Gulls (*Larus philadelphia*) and Gray Jays (*Perisoreus canadensis*) moved off, the juvenile was released and photographed on the moss under a small plant. As I was leaving the bog, I heard a singing Blackpoll Warbler some 150 m SE of the DBS area and 200 m S of where the first Blackpoll was heard on 4 July. This was probably another individual of this species.

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Initial Post-Release Behavior of Marten, *Martes americana*, Introduced in Cypress Hills Provincial Park, Saskatchewan

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The behaviour of eight female Martens (*Martes americana*) with kits was compared to that of five single adults during and immediately after release in Cypress Hills Provincial Park, Saskatchewan, in June 1986. Females with kits, in contrast to single adults, were cautious in leaving their holding facility and investigated the release site vicinity in search of a den. All families relocated themselves in the vicinity of holding facilities, which they still used for shelter or visited for food and water. Litters were not abandoned. Single adults quickly left the release site, even after a six-day pre-release period on site, and were never seen again. This study suggests that, upon release, females with dependent young may be more likely to remain in the immediate area of their release than single adults.

Key Words: Marten, *Martes americana*, post-release behaviour, introduction, Cypress Hills, Saskatchewan.

Marten (*Martes americana*) reintroductions have been made in several locations in North America (Davis 1983; M. C. Bateman. 1985. Termination Report on the Atlantic region Marten re-introduction program. Canadian Wildlife Service Report, Sackville, New Brunswick. 10 pages) and usually involved single adults that were monitored afterwards by radio-telemetry, tracking in snow and live-trapping. However, data on the behaviour of Martens during and immediately after release are lacking for family groups as well as single adults. Davis (1983) suggested that movements of female Martens with dependent young would be concentrated in the immediate release area, but he did not have data to substantiate his views.

The objective of the present study was to record and compare the behavior of adult female Martens with kits of different ages with that of single adults immediately after their release in Cypress Hills Provincial Park, Saskatchewan. The Cypress Hills (49° 36′N, 109° 55′W) are an "island" land form rising to 1400 m above sea level, forested with mature coniferous and mixed stands, and surrounded by the mixed-grass prairie of southwestern Saskatchewan and southeastern Alberta.

Methods

Martens were live-trapped in fall 1985 in central Alberta (nine females, three males) and Yukon (one male) and held in captivity from 192 to 254 days for behavioral studies at the Alberta Environmental Centre. They were released 23-25 June 1986, along with twenty 48-64 day-old-kits (10 males and 10 females from eight families) born in captivity. The release sites consisted of mature conifer stands interspersed with deciduous trees along drainages with available water. With their respective two-chambered nest boxes (61 x 51 x 41 cm) placed under conifer trees and connecting 2.5 cm wire-mesh holding pens (1.0 x 0.6 x 0.5 m) set in the open, females and kits were kept at the release sites for three to four days prior to release; adult males, five to six days; and a single adult female, two days. Commercial mink food and water were provided daily from 19 to 28 June.

In four areas, single adult males were released between two family release sites. The single adult female was released between two of these areas. Families were released first to permit females to scent-mark their home ranges prior to release of males. Males were released next, followed by the single female. It was hoped that dependent young would hold females to the release areas and that female scent-marks would draw males back to release areas for breeding.

On the day of the releases, the holding pens were disconnected from the nest boxes just enough to allow Martens to exit but prevent the entry of Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*). The time spent by an animal to leave its nest box completely (i.e., four paws on the ground) from the moment it had been disconnected from the holding pen was defined as nest box exit duration. All observations were made from a distance.

The initial post-release behavior was recorded with a portable Panasonic AG-100 video camera (Avicom Industrial Communications, Edmonton). The area under observation, approximately 6 m², consisted of the nest box and holding pen and the immediate surroundings. Each release was videotaped for two to six hours. Nonparametric statistics such as Kruskal-Wallis one-way analysis of variance by ranks and the Mann-Whitney U test were used to analyze the data (Siegel 1956).

Results and Discussion

The exit duration of adults with litters (25 seconds to 42:20 minutes; $\bar{x} = 476$ seconds) was significantly ($P < 0.05$) longer than that of single adults (14 seconds to 1:33 minutes; $\bar{x} = 48$ seconds). Adults with litters were generally more "cautious" than single adults when exiting the holding facilities, i.e., they stopped to look around, smelled the ground and sniffed the air, and then slowly left the nest box, one foot at a time.

Exit durations of females with different age litters did not significantly ($P > 0.05$) differ. However, the exits of 48-, 52- and 54-day-old kits (53 minutes to 5:51 hours) were significantly ($P < 0.05$) longer than those of 56-, 61- and 64-day old kits (3 min to 23 min). Older kits (≥ 56 days old) did not hesitate to leave their nest box and explore a wider area, often out of sight of the camera. Their climbing skills also appeared to be better developed than those of younger kits.

The initial adult exploratory period varied from 45 seconds to ≤ 25 hours. All families used the holding facilities and explored the immediate vicinity for ≥ 1.6 hours after exiting the nest box. The nest box was used as shelter by the kits of one family for 21-25 hours and by another family for three days (until inadvertently disturbed by observers). All families eventually established nests away from the holding facilities but two of them came back for three days after leaving their nest box to consume the commercial food and water left by the holding pen.

Four of the five single adults left the vicinity of the holding facilities within 30 min; one adult male remained in the immediate vicinity of the holding facility for at least two hours. However, once single adults left the release site, they did not return to their nest box/holding pen for food, water or shelter.

This release differed from those of previous studies (Davis 1983; M. C. Bateman. 1985. Progress report, marten re-introduction to Fundy National Park. Canada Wildlife Service Report, Sackville, New Brunswick. 25 pages; B. G. Slough, and C. M. M. Smitts. 1985. Yukon marten management. Progress to August 1985. Fish and Wildlife Branch, Yukon Department of Renewable Resources Report, Whitehorse, Yukon Territory. 57 pages.) because of the long period of captivity of the animals before transport, which permitted the Martens to become acclimated to human presence/activity as well as their nest box/holding pens. Also, all adults exited the nest box ≤ 42 minutes, even when observers remained in the vicinity of the holding facilities.

This contrasted with Bateman's (see above) observations of Marten which, after a holding period of only 54 to 74 days, did not exit the holding facilities while being observed. Martens also had time to establish bonds with their kits and, contrary to J. D. Quann (1985. Progress report Fundy National Park American Marten reintroduction program. Fundy National Park Report, Sackville, New Brunswick. 34 pages.), who reported litter abandonments among Martens that had given birth upon release, all adult females came back from their distant investigations to pick up their kits. Pulliainen (1986) found that after two years of captivity, a male Marten re-established its hunting behavior after release. In this study, one Marten was recorded bringing a small mammal to the nest box on two separate occasions. The fact that most of the Marten did not use supplied food also suggests that hunting skills were retained.

Proulx (unpublished data) found that single adult Martens that became acclimated to a simulated natural environment in two days exited their nest box in < 60 seconds, as did the Martens in the current study. Therefore, it appears that the two to six day pre-release period prescribed for single adults was long enough to reduce considerably the fear drive evoked by the new environment (Montgomery 1955) and to permit the animals to exit their nest box without prolonged delays.

However, even after a six-day pre-release period, single adults ran away from their release site and never came back for food, water or shelter. Site fidelity may not be related so much to the duration of the pre-release period as it is to the characteristics of the animals released. It was not possible, in this study, to assess how far families went. However, the fact that kits of families that had left the release site came back to consume food and water left outside the holding pen suggested that females did not locate their family far from the release site.

Females with kits, contrary to single adults, intensively investigated the release site surroundings in search of a den. Therefore, this study supports the view of Davis (1983) that movements of female Martens with dependent young would concentrate in the immediate area of their release. Wiggett and Boag (1986) also found that introduced Columbian Ground Squirrels (*Spermophilus columbianus*) with dependent young may be more likely to settle in the vicinity of the release site than those without young.

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Beaver, *Castor canadensis*, Mortality Caused by Felled Trees in Alberta

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Scotter, George W., and Etta Scotter. 1989. Beaver, *Castor canadensis*, mortality caused by felled trees in Alberta. Canadian Field-Naturalist 103(3): 400–401.

The deaths of two Beaver, *Castor canadensis*, caused by felled trees are reported from Alberta.

Key Words: Beaver, *Castor canadensis*, Alberta.

On the afternoon of 13 October 1986 we found a large "blanket-sized" Beaver (*Castor canadensis*) along a trail on the east side of Whitemud Creek, Edmonton, Alberta, which had been killed by a felled tree. The trail is immediately below our house and as we were using it almost daily we believe the accident happened during the previous night.

The felled Balsam Poplar (*Populus balsamifera*) which killed the Beaver was 36 cm in diameter at the base with a dbh of 26 cm. The trunk hit the beaver across the shoulders about 7 m from where the tree had been cut. Death of the Beaver, probably from a broken back, likely was instantaneous as there was no evidence that the animal tried to dig itself out from under the tree. The Beaver may have misjudged where the tree would fall or another Beaver could have been cutting it. An additional possibility is that the partly cut tree was dislodged by wind.

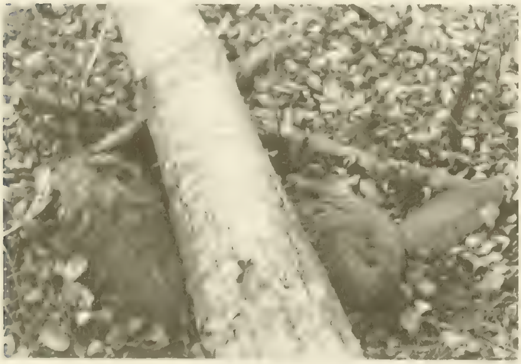

FIGURE 1. A male Beaver killed by a fallen aspen north of Gibbons, Alberta in mid-October 1978 (Photo by Harley Coleman).

Harley Coleman, a pest control officer with the Municipal District of Sturgeon, told us of a similar happening about 8 km north of Gibbons, Alberta. He found a Beaver that had been killed by a fallen Aspen (*Populus tremuloides*). The tree, 20 cm at the base, hit the Beaver across the upper back about 1 m from the stump (Figure 1). The Beaver was a male 3 or 4 years old and weighed about 18 kg. It was carrying a dry stick about 5 cm thick and 1 m long in its mouth (Figure 1). That suggests another Beaver cut the fallen tree or that it was dislodged by the wind. Although Mr. Coleman has trapped more than 3000 Beaver, this is the only occasion on which he found Beaver killed by a tree.

Beaver deaths caused by felled trees do not appear to be a common occurrence. Hitchcock (1954) reported one such death in Vermont. Ellarson and Hickey (1952) described the trapping of a Beaver when the tree it was felling landed on one of its hind feet. Felled trees were not considered as a mortality factor in Hill's (1982) review paper on Beaver.

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Interactions of Southern Flying Squirrels, *Glaucomys volans*, and Cavity-nesting Birds

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Four field observations supplement historical references in documenting an apparent hierarchical relationship between Southern Flying Squirrels (*Glaucomys volans*) and cavity-nesting birds. Larger, more aggressive birds may oust flying squirrels or allow them to coexist in adjacent cavities, whereas smaller birds may be killed or ousted by the squirrels.

Key Words: Southern Flying Squirrel, *Glaucomys volans*, cavity-nesting birds, interactions, Northern Flying Squirrel, *Glaucomys sabrinus*.

The Southern Flying Squirrel (*Glaucomys volans*) is widely distributed in forests of eastern North America (Dolan and Carter 1977), and is both a potential predator and nest-site competitor of cavity-nesting birds (Wells-Gosling 1985). Published accounts of flying squirrel-bird interactions note that aggression is often involved, but there has been little discussion of how these encounters differ among bird taxa. In this note we report on four observations from Ontario and Quebec which supplement historical accounts of flying squirrel-bird interactions, and comment on the nature of such encounters. We propose that a hierarchy exists in the cavity-nesting community of eastern forests. Smaller birds may suffer mortality or disturbance from flying squirrels encountered in cavities, whereas larger birds tend to tolerate flying squirrels or even oust them from desirable nest sites. Our observations were documented during research on the status and ecology of the Southern Flying Squirrel (*G. v. volans*) in Canada (M. A. Stabb 1987. The status of the Southern Flying Squirrel, *Glaucomys volans*, in Canada. Unpublished ms. Ontario Ministry of Natural Resources, Toronto), which included extensive daytime searches of cavity trees in southern Ontario during 1985-1986.

On 17 June 1985, a Southern Flying Squirrel was found in a 1.5 m high Red Pine (*Pinus resinosa*) stub in a young Red Pine plantation in the Regional Municipality of Haldimand-Norfolk, Ontario (42°45′N, 80°34′W). Upon discovery, the squirrel scurried out of a small hole just below the top of the stem and leapt to a nearby pine. The stub contained the apparently abandoned nest of a Black-capped Chickadee (*Parus atricapillus*). Fresh eggshell fragments collected from beneath the hole of the stub were identified as those of a chickadee (Harrison 1975). The stub was the shortest of more than 120 trees found to harbour Southern Flying Squirrels during the 1985-1986 searches (M. A. Stabb, unpublished), and was located in sub-optimal Southern Flying Squirrel habitat. Flying squirrels have preyed on eggs and young of Eastern Bluebirds (*Siala sialis*) in nest boxes (Golley 1962; Goertz et al. 1975), so we speculated that the squirrel was roosting in the cavity after having eaten the chickadee eggs. No signs of adult chickadees or of their remains were seen in or near the stub. Chickadees may recognize flying squirrels as potential (egg) predators, as we have twice observed Black-capped Chickadees scolding Southern Flying Squirrels that had been disturbed from trees in other forests during daylight hours.

On 22 March 1985, a male Southern Flying Squirrel was found occupying a cavity near the top of a 5 m high dead poplar (*Populus* sp.) stem in a deciduous forest in the Regional Municipality of Haldimand-Norfolk, Ontario (42° 39′N, 80° 35′W). The feathered remains of a Downy Woodpecker (*Picoides pubescens*) were found incorporated into the bedding material of a nest in the cavity. Hole height and size corresponded with those of Downy Woodpeckers. Southern Flying Squirrels have usurped newly-excavated holes of Hairy Woodpeckers (*Picoides villosus*) (Kilham 1968) and Red-cockaded Woodpeckers (*Picoides borealis*) (Jackson 1978; Hooper and Lennartz 1983) without killing the birds, although they have killed and eaten a Yellow-bellied Sapsucker (*Sphyrapicus varius*) in captivity (Stoddard 1920), a House Sparrow (*Passer domesticus*) in captivity (Mumford and Whitaker 1982), and Purple Martins (*Progne subis*) in a bird house (Bailey 1923).

On 9 July 1985, we slapped the base of a 10 m high barkless dead elm (*Ulmus* sp.) stem in an open hardwood stand in Pinery Provincial Park, Ontario (43° 15′N, 81° 53′W). A Red-headed Woodpecker (*Melanerpes erythrocephalus*) emerged from a cavity 9 m up the stem and flew about overhead, calling and obviously agitated. Tree and cavity characteristics, time of year, and behaviour of the bird indicated that the woodpecker was nesting. The bird returned to the cavity within 10 min. Prior to the return of the woodpecker the tree was slapped again and three Southern Flying Squirrels crawled from a hole 6 m high in the same stem. One squirrel that glided down to a nearby tree was of juvenile size and pelage. The fresh, circular hole was visually estimated at 4 to 6 cm in diameter and was obviously smaller than the hole used by the Red-headed Woodpecker. Cavity entrances within the above range are preferred by Southern Flying Squirrels owing to nest site competition for larger holes with the Grey Squirrel (*Sciurus carolinensis*) (Doby 1984). Fresh remains of a woodpecker were found at the base of the dead stem; the plumage was of the genus *Picoides* and the skull and beak identified the bird as a Hairy Woodpecker. The woodpecker's body was dishevelled, but we saw no tooth marks or other evidence on the skeleton to indicate that the bird had been eaten. Southern Flying Squirrels have nested in the same tree concurrently with Red-cockaded Woodpeckers (Dennis 1971), Hairy Woodpeckers and Yellow-bellied Sapsuckers (Kilham 1971), and in the same Purple Martin house as a Common Flicker (*Colaptes auratus*) and a number of other birds (Lowery 1974). A group of at least twenty Southern Flying Squirrels, likely a winter aggregation, was reported living in a large Purple Martin house also occupied by six Eastern Screech Owls (*Otus asio*) (Audubon and Bachman 1851).

In early May 1967, a flying squirrel was observed at midday being evicted by a European Starling (*Sturnus vulgaris*) from a cavity in a beech tree (*Fagus grandifolia*) at the east end of Montreal Island, Quebec (45° 40′N, 75° 32′W). This cavity had two openings, permitting the starling to enter one opening and evict the resting squirrel from the other. The starling chased the squirrel in an upward spiral about the tree until the squirrel disappeared into a third hole. The beech stem was one of about five large trees standing in a clump surrounded by an open area; there were few other local nesting opportunities. Red-bellied Woodpeckers (*Melanerpes carolinus*) have been similarly observed physically removing first nest material and then an adult Southern Flying Squirrel from a tree cavity (Stickel 1963). In the same account, no agonistic behaviour was observed between the squirrel and a pair of Hairy Woodpeckers also nesting in the tree.

The species was not determined in the Quebec observation and could not be assigned using range maps because both the Southern and Northern Flying Squirrel (*G. sabrinus*) have been found in the Montreal region. *G. volans* and *G. sabrinus* would not necessarily have similar relations with starlings or other cavity-nesting birds. The larger *G. sabrinus* tends to use cavities with larger entrances, such those made by Flickers (Erskine and McLaren 1972), which would reduce encounters with smaller cavity-nesting birds. *G. sabrinus* does eat eggs and roosting birds (Wells-Gosling and Heaney 1984), but they have also taken over cavities with active nests of Buffleheads (*Bucephala albeola*) without eating the eggs inside (Erskine 1971). *G. volans* is known to be more aggressive in defending nest cavities, at least against conspecifics (Weigl 1978), and can be an important cavity-competitor of birds such as the endangered Red-cockaded Woodpecker (Jackson 1978).

Documented interactions between Southern Flying Squirrels and other cavity-nesters often occurred in artificial nesting structures or in captivity. In the wild, *G. volans* may kill cavity-nesting birds opportunistically or to obtain possession of a cavity, but it is unlikely that the squirrel regularly kills adult birds for food. Smaller birds such as the Black-capped Chickadee and Downy Woodpecker would be less capable of defending themselves or their nests from *G. volans* than would larger cavity-nesters such as starlings and Red-bellied Woodpeckers. *G. volans* may actively take birds' eggs or nestlings, especially those in cavities, as has been observed in the Red Squirrel (*Tamiasciurus hudsonicus*) (Gibbon 1970 *in* Erskine and McLaren 1972) and the Grey Squirrel (Carey and Gill 1983).

The fact that *G. sabrinus* has taken over active nest sites of the much larger Bufflehead (Erskine 1971) suggests that a dominance hierarchy, if present, may not be based on size alone, or may differ between the two flying squirrel species. Tree cavities are often a limited resource for the cavity-nesting wildlife guild (Thomas et al. 1979), so the degree of interaction between species is likely influenced by availability of these potential nest sites. A scarcity of nest sites may increase the aggressive nature of interactions and the aggressive response of squirrels.

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Range Extension of the Fairy Shrimp *Polyartemiella hazeni* (Murdoch, 1884) (Crustacea: Anostraca) to the Eastern Canadian Arctic, with Notes on the Distribution of Other Eastern Arctic Anostraca

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Billington, Neil, Marc G. Boileau, and Paul D.N. Hebert. 1989. Range extension of the fairy shrimp *Polyartemiella hazeni* (Murdoch, 1884) (Crustacea: Anostraca) to the eastern Canadian Arctic, with notes on the distribution of other eastern Arctic Anostraca. Canadian Field-Naturalist 103(3): 404–405.

Two populations of *Polyartemiella hazeni* (Murdoch, 1884) were collected from ponds near the western coast of Hudson Bay, one from Rankin Inlet, Northwest Territories, and the other from Eskimo Point, Northwest Territories. These are the first records of this fairy shrimp species (hitherto considered to be limited to the western arctic) east of 117° W and represent an easterly range extension of 1300 km. New site records in the eastern Canadian Arctic are also provided for two other fairy shrimp species, *Artemiopsis stefanssoni* (Johansen, 1921) and *Branchinecta paludosa* (O. F. Müller, 1788). In addition, it was noted that under some circumstances *B. palludosa* produce more than a single generation per year in ponds at Churchill, Manitoba.

Key Words: Anostraca, Fairy Shrimps, *Polyartemiella hazeni*, range extension, eastern Canadian Arctic, *Artemiopsis stefanssoni, Branchinecta paludosa.*

Specimens of the fairy shrimp *Polyartemiella hazeni* (Murdoch, 1884) were collected from a pond at Rankin Inlet, Northwest Territories (92°05′ W, 62° 49′ N) in July 1977 and again on 15 August 1985. This was initially considered to be a disjunct population (Hebert and Hann 1986) of a species restricted to the western arctic (Johansen 1921; Daborn 1976, 1978), with the exception of a single alpine record (Daborn 1976). In fact, this species has not previously been collected east of 117° 19′ W (Daborn 1976). We have subsequently collected specimens from an additional population of *P. hazeni* at Eskimo Point, N.W.T. (94° 04′ W; 61° 06′ N). Reference specimens from both populations have been deposited in the Canadian Museum of Nature (Table 1).

The presence of a population of *P. hazeni* from another site along western Hudson Bay indicates that the Rankin Inlet population was not a disjunct record. Furthermore, these occurrences suggest that this species may be distributed throughout the mainland Northwest Territories. Few surveys of pond habitats have been undertaken in the interior of the Keewatin District, which may explain why *P. hazeni* has remained unrecorded in this region. Our two records of *P. hazeni* represent an easterly range extension of approximately 1300 km.

At Rankin Inlet, *P. hazeni* coexisted with *Branchinecta paludosa* (O. F. Müller, 1788), while at Eskimo Point *P. hazeni* coexisted with both *B. paludosa* and *Artemiopsis stefanssoni* (Johansen, 1921). *A. stefanssoni* and *B. paludosa* were found either separately, or co-occurring in other ponds at both these sites.

We also report new site records for, and additional observations on, two other eastern arctic fairy shrimp species. Specimens of *Artemiopsis stefanssoni* were collected from Rankin Inlet, Eskimo Point and Igloolik, N.W.T. (81° 48′ W; 69° 22′ N) (Table 1), with the two former sites representing new records. *A. stefanssoni* has been found largely in the Canadian Arctic archipelago and the extreme northern parts of mainland Northwest Territories (Daborn 1977, 1978; Hebert and Hann 1986). These two new records from western Hudson's Bay and a single alpine record from a pond in the Banff National Park (Hartland-Rowe and Anderson 1968) now suggest that *A. stefanssoni* may also be more widely distributed throughout the Canadian Arctic.

Branchinecta paludosa is widely distributed throughout the Canadian Arctic and sub-arctic (Ferguson 1935; Daborn 1978; Hebert and Hann 1986). Reference specimens collected from sites in the eastern arctic (Igloolik and Eskimo Point), for which new records were noted by Hebert and Hann (1986), have been deposited in the Canadian Museum of Nature (Table 1).

B. paludosa has traditionally been regarded as a univoltine species (Johansen 1921). However, observations at Churchill, Manitoba have shown that in some years *B. paludosa* may produce more than one cohort. Typically, *B. paludosa* hatch as nauplii at the time of ice-melt (late-May/early June in Churchill), reach sexual maturity in 4-5 weeks and often persist until ponds either dry out or re-freeze (Johansen 1921; Ferguson 1935).

TABLE 1. Reference specimens of fairy shrimps (Anostraca) collected from the eastern Canadian Arctic 1984-1987. Specimens are deposited in the Canadian Museum of Nature (formerly the National Museum of Natural Sciences, National Museums of Canada), Ottawa.

Species	Location	Date Collected	Catalogue Number
Polyartemiella hazeni	Rankin Inlet, N.W.T. (92° 05′ W, 62° 47′ N)	15 August 1985	NMC-C-1986-425
	Eskimo Point, N.W.T. (94° 04′ W, 61° 06′ N)	28 July 1987	NMC-C-1987-854
Artemiopsis stefanssoni	Eskimo Point, N.W.T.	28 July 1987	NMC-C-1987-853
	Rankin Inlet, N.W.T.	16 August 1986	NMC-C-1987-849
	Igloolik, N.W.T. (81° 48′ W, 69° 22′ N)	16 August 1986	NMC-C-1987-851
Branchinecta paludosa	Churchill, Manitoba (94° 11′ W, 58° 47′ N)	9 September 1984	NMC-C-1987-845
	Eskimo Point, N.W.T.	30 July 1985 28 July 1987	NMC-C-1987-847 NMC-C-1987-852
	Rankin Inlet, N.W.T.	15 August 1985	NMC-C-1987-848
	Igloolik, N.W.T.	13 August 1985	NMC-C-1987-1103

Many rock bluff ponds at Churchill dry up by mid-July, except during very wet summers, but often become re-filled by late-August rainfall. Under these circumstances, a second hatch of *B. paludosa* has been observed and these individuals reach sexual maturity by mid-September (N. Billington, personal observation). Donald (1983) observed similar second hatches of the eggs of this species in a temporary pond near Calgary, Alberta. These observations suggest that the hatch of *B. paludosa* resting eggs can be stimulated either by desiccation and re-hydration of eggs, or by freezing and thawing. In fact, desiccation and re-hydration have been shown to stimulate hatching in other *Branchinecta* species (Donald 1983). However, as many ponds at Churchill containing *B. paludosa* do not appear to dry out (P. Hebert, personal observations over a 10-year period), possibly both hatch stimulation mechanisms operate in this species. The ability of *B. paludosa* to produce more than one generation per year when conditions again become favorable likely enhances its persistence in intermittent habitats.

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Gray Jays, *Perisoreus canadensis*, and Common Ravens, *Corvus corax*, as Predators of Winter Ticks, *Dermacentor albipictus*

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Addison, E. M., R. D. Strickland, and D. J. H. Fraser. 1989. Gray Jays, *Perisoreus canadensis*, and Common Ravens, *Corvus corax*, as predators of Winter Ticks, *Dermacentor albipictus*. Canadian Field–Naturalist 103(3): 406–408.

Ravens, *Corvus corax*, and, to a lesser extent, Gray Jays, *Perisoreus canadensis*, foraged for and ate engorged female Winter Ticks, *Dermacentor albipictus*, that had detached from infested captive Moose, *Alces alces*. Two Gray Jays were observed to perch on the back of a Moose in the wild and peck within the hair coat. When presented with engorged ticks, jays readily seized and apparently stored them. Winter Ticks also were found in an occupied Gray Jay nest.

Key Words: Common Raven, *Corvus corax*, Gray Jay, *Perisoreus canadensis*, Winter Tick, *Dermacentor albipictus*, Moose, *Alces alces*, predation, food caching, Ontario.

Birds are recognized as predators of ticks in North America, yet the documented evidence is sparse. Hardy (1869) referred to Gray Jays, *Perisoreus canadensis*, in Nova Scotia as "moose birds" and described how they collected Winter Ticks, *Dermacentor albipictus*, which had dropped from Moose, *Alces alces*, onto snow. Although a Robin, *Turdus migratorius*, has been documented as pecking at a tick (Wilkinson 1970), most reports of avian predators of ticks in North America are of corvids.

Scrub Jays, *Aphelocoma coerulescens*, which landed on and pecked in the hair of Black-tailed Deer, *Odocoileus hemionus columbianus*, were thought to be eating ectoparasites, including ticks (Dixon 1944; Schulz and Budwiser 1970; Isenhart and DeSante 1985). Black-billed Magpies, *Pica pica*, have been thought, or known, to feed on ticks when perched on the backs of Bighorn Sheep, *Ovis canadensis* (Stelfox 1968); domestic cattle, *Bos taurus*, (Wilkinson 1969); Wapiti, *Cervus elaphus*, and Mule Deer, *Odocoileus hemionus* (Linsdale 1946). Green (1949) recovered 3-16 ticks from each of six magpies. Most records were speculative and there are few records of birds seen picking up and eating ticks.

We raised Moose calves in captivity within Algonquin Provincial Park, Ontario [45°33′N, 78°35′W] (Addison et al. 1983). In September and October 1981, three Moose were each infested with approximately 21 000 larval Winter Ticks (*see* McLaughlin and Addison 1986) and one Moose was given no ticks. Holding pens for Moose contained many mature trees. Enclosed booths for remote observation of Moose were built on raised platforms behind the pens. Winter Ticks were first observed to detach from Moose in late March (Addison and McLaughlin 1988). Moose were observed for 50 h monthly, including between 07:00 and 17:00 EST on 8 to 12 March and 1 to 7 April 1982.

No birds foraged on the ground or snow within the pens during the March observation period. Common Ravens made up 52 of 62 records of birds on the ground in the pens in April, with 8 records of Gray Jays, and 2 of Blue Jays, *Cyanocitta cristata*. At any one time there were up to 3 Ravens, 2 Blue Jays, or 3 Gray Jays present. The latter were an apparent family group consisting of two adults that had been colour-banded by R.D.S. and an unbanded bird, which may have been their young of the previous year. Most visits lasted for 1-3 min but there were ground foraging bouts of 10, 12, and 24 min. The food picked up by Blue Jays could not be seen on their two foraging visits. Common Ravens and Gray Jays often were seen to eat oats which had dropped from the Moose feeder onto the ground or were present in an undigested form within the loose feces of some Moose. However, ravens and Gray Jays were observed to collect and eat or retain ticks on nine and four different visits, respectively. One raven collected six engorged female ticks during one visit. A raven was observed with a "mouthful" of ticks on another occasion. Upon their arrival at the pens, ravens and Gray Jays usually checked bedding sites of Moose and red spots on the snow (from the bloody excreta of ticks) before checking other areas. Ticks were often concentrated in the area of beds where Moose had lain for 1 to 2 h.

Gray Jays may not have foraged for ticks as frequently as ravens because they are subordinate to ravens and did not visit the pens when ravens were there. Ravens from a very large area may have visited the pens as they are not strongly territorial while foraging. With the more territorial Gray Jays, it was likely that only the local pair and their young would have had access to the pens under most conditions.

There were no records of birds landing or feeding on oats within the pen of the control Moose that harboured no ticks. In contrast, 30 records were made during the same observation periods of birds foraging on the ground of the adjacent pen containing an infested Moose.

Ravens and jays were not observed to land on the captive Moose and were seen no closer than 3 m from a Moose. A Moose responded aggressively to the presence of ravens on two occasions. In the first instance, the Moose walked towards the raven with ears back and head lowered in a threat posture. The Moose quickened its pace to a trot, then to a full charge, and pawed at the raven with a forefoot as the bird flew from the ground. Thirty minutes later the same Moose walked toward two Ravens on the ground and flushed them into trees.

Four observations of Gray Jay — tick relationships were made in the wild. On 14 April 1982 conservation officers A. Terry and G. Oram saw, from a distance of 75 m, two Gray Jays land on the back and rump of a bull Moose near Ryan Lake, Algonquin Park. The jay at the rump immediately moved to, and started pecking at, the anal area of the moose. The Moose then moved away and the two jays left. Ticks were not seen on the Moose and the jays were not observed with ticks in their bills. Nevertheless, the severe hair loss of the Moose and the commonly observed concentrations of Winter Ticks in the anal region of Moose during late March and April suggest that the jay pecking in that region may have been foraging for Winter Ticks.

On 16 April 1982, R. D. S. observed two colour-banded Gray Jays (minimum ages of 5 and 3 years) foraging 50 m from their nest, which contained two 11-day-old nestlings. They passed within 2 m of a severely tick-infested bull Moose feeding in a ditch. The jays moved slowly from perch to perch, peering down at the ground 2-3 m below. Occasionally they flew down to bare patches on the ground but were not observed to pick anything up. Gradually the Moose and the two jays diverged, with the jays having shown no fear of the Moose or any evidence of recognizing the abundant engorged ticks which it carried.

On 2 May 1981, R.D.S. and M. Pageot attracted a pair of jays by offering bread. Eleven engorged Winter Ticks that had been refrigerated for 14 days were then placed along with more bread on a white sheet on the ground. The jays ignored the bread and unhesitatingly picked up the ticks, sometimes one at a time but as many as three in rapid succession. After "swallowing" the ticks, or at least moving them back into their throats, the jays made short flights into the forest before returning quickly for more. This behaviour is typical of Gray Jays that are storing food (Dow 1965; Rutter 1969) but only one definite storage event was observed. A jay collected the last tick and a piece of bread, flew to the forest, and cached food behind a large curl of bark of White Birch, *Betula papyrifera*. It could not be established if the bread, the tick, or both were stored. The jays were not seen to peck at, or otherwise immobilize, the ticks before picking them up. The absence of blood on the bills and plumage of the jays suggests that the ticks may have been stored intact and alive.

On 25 April 1984 at 17:30, R.D.S. found a female Gray Jay near Cache Lake, Algonquin Park, brooding her three hatchlings and three very warm ticks. One tick was alive with legs moving when withdrawn from the nest. The remaining two ticks were darker in colour and dead. All three ticks were *Dermacentor albipictus* and weighed between 0.65 and 0.88 g, the size of fully engorged female Winter Ticks which detach from Moose in Algonquin Park (Addison and McLaughlin 1988). None of the ticks showed signs of injury, and the two dead ticks may well have been found by the jay frozen to death on the snow. Detachment of engorged female Winter Ticks from captive Moose started on 15 March in 1984 and continued through April and into May. Nothing definite could be concluded about the origin of the live tick.

This was the only occasion among several hundred opportunities on which ticks or any other potential food items were seen in dozens of Gray Jay nests observed closely by R.D.S. in Ontario and Quebec from 1967 to 1987. Most nests were examined much earlier in the day. Storage of food in nests by incubating or brooding female Gray Jays might plausibly be missed if the behaviour serves mainly to provide a night-time food supplement and only occurs late in the day. The ticks were far too large to be used as food for the nestlings.

Another, not mutually exclusive hypothesis for the benefit of such behaviour is that the engorged ticks served as "hot water bottles" for the hatchlings. This could benefit the hatchlings during short absences of the female from the nest. (At the time of the observation the combined tick mass was approximately 15% of the total nestling mass.) Whatever the explanation, we are unaware of similar behaviour being reported in any other wild passerine.

In areas with dense populations of Moose infested with Winter Ticks, the ticks would seem to be an ideal food for nesting Gray Jays, which have no similarly obvious sources of food during their late winter, March-April breeding season. The average Gray Jay nestling period in Algonquin Park is 12 April-5 May (R.D.S., *unpublished*), which is within the mid-March to late May period when engorged Winter Ticks detach from Moose within the park. Our observations do not establish how prevalent this behaviour might be, but they do suggest that engorged Winter Ticks are recognized and utilized by both Gray Jays and Common Ravens, at least after detachment from Moose.

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A Cougar, *Felis concolor*, Kitten Killed and Eaten by Gray Wolves, *Canis lupus*, in Glacier National Park, Montana

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The partly consumed body of a freshly-killed Cougar (*Felis concolor*) kitten was discovered along the tracks of a Gray Wolf (*Canis lupus*) pack in Glacier National Park, Montana. Tracks indicated that the wolves chased and killed the kitten after it left the security of a large conifer where it had been treed.

Key Words: Gray Wolf, *Canis lupus*, Cougar, *Felis concolor*, Glacier National Park, Montana.

Adult Gray Wolves (*Canis lupus*) and Cougars (*Felis concolor*) have few natural enemies: however the young of both species are vulnerable to predation. We found only one significant wolf-cougar interaction reported in the literature: an adult female wolf was killed by a Cougar near Nordegg, Alberta in March 1985 (Schmidt and Gunson 1985). We failed to find any record of wolves killing Cougars. Wolves are known to occasionally kill Red Foxes (*Vulpes vulpes*) (Allen 1979; Mech 1970), Wolverines (*Gulo gulo*) (Burkholder 1962), Coyotes (*Canis latrans*) (Fuller and Keith 1981), and Black Bears (*Ursus americanus*) (Rogers and Mech 1981). We report here a description of a Cougar kitten killed and partly consumed by Gray Wolves in Glacier National Park, Montana.

Several members of a wolf pack in Glacier National Park were radio-collared and their movements, feeding habits, and population dynamics were monitored. Instrumented wolves were radio-located daily during winter, and their travel routes were followed on skis or snowshoes.

This pack entered the Anaconda Creek drainage on 22 January 1987 and left the area the following day. Two cm of snow fell 22-23 January creating excellent tracking conditions. One of us (PAW) tracked 4-5 pack members in the Anaconda Drainage on 24 January. The following description of events was reconstructed after a thorough search and mapping of all tracks in the area.

Numerous wolf tracks encircled a 10-m tall Douglas-fir (*Pseudotsuga menziesii*). A single set of small Cougar tracks emerged from beneath the tent-like lower branches and headed east. The Cougar tracks immediately merged onto a well-used wolf trail. Fifty meters from the tree, tufts of kitten fur and increasingly larger splotches of blood marked the trail, ending in four wolf beds containing kitten bone fragments. The majority of Cougar remains were found 150 m south of the fir tree on flat ground beneath a stand of Quaking Aspens (*Populus tremuloides*).

The remains of a White-tailed Deer (*Odocoileus virginianus*) were found 300 m south of the kitten carcass. A large pile of plucked deer hair found under a spruce tree indicated a Cougar had fed upon, and possibly killed the deer. However, Gray Wolves had subsequently consumed the deer and wolf tracks obliterated evidence of other predators at the site. This Cougar was very likely the mother of the kitten killed nearby, although no adult Cougar tracks were found.

The Cougar carcass was thawed and necropsied on 8 February 1987. The total body length without the tail was 57 cm; the cougar was probably 2-3 months old as evidenced by this small body size, tooth eruption pattern, and the heavily spotted coat. Sex could not be determined. Approximately 70% of the hide remained intact. All organs and muscular tissue from the spine were gone. Both femurs were broken and both lower hind legs were missing. The cranium was opened from the atlas to 1 cm posterior to the eyes with a gelled, red hemorrhage between the eyes. The neck musculature was exposed ventrally 11 cm from mid-mandible to chest entry. Bruising and pooling of blood was evident in the musculature dorsal to the missing esophagus and trachea. Numerous other puncture wounds and hemorrhages were found in the neck, spine, rib cage, and shoulder areas. These wounds are indicative of a bite and shake attack method known to be used by wolves when handling medium-sized prey (Allen 1979).

Wolves and Cougars share a similar prey base and use many of the same travel routes in the Glacier National Park Ecosystem. Fatal encounters between the two species probably occur occasionally, but the chance of finding evidence of such encounters is minimal.

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Food-storage in Artificial Nest-boxes by the White-footed Mouse, *Peromyscus leucopus*

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Popp, James W. 1989. Food-storage in artificial nest-boxes by the White-footed Mouse, *Peromyscus leucopus*. Canadian Field–Naturalist 103(3): 410–411.

White-footed mice, *Peromyscus leucopus*, are known to store food, but little is known of this behavior outside of the laboratory. In this study, I investigated the use of artificial nest boxes as food-storage sites in a wild population of *P. leucopus* during the fall and winter. Storage or caching of nuts was done primarily during the fall and appeared to end by late December. Consumption of stored nuts took place throughout the fall and winter. Nest-boxes were also used for day refuges but, a single nest box was rarely used for both food-storage and as a day refuge.

Key Words: White-footed Mouse, *Peromyscus leucopus*, food-storatge, artificial nests, Wisconsin.

White-footed Mice, *Peromyscus leucopus*, are known to store or cache food (Howard and Evans 1961; Barry 1976; Tadlock and Klein 1979; Sanchez and Reichman 1987). Most studies of food-storage behavior in this species, however, have been laboratory studies and little is known about food-storage in natural populations. Here, I report on the use of artificial nest-boxes by *P. leucopus* for storing Shagbark Hickory (*Carya ovata*) nuts during the fall and winter. In particular, I examined seasonal differences in the creation and usage of food caches and the relationship between the use of nest-boxes for food-storage and day refuges.

Methods

The study was conducted at the University of Wisconsin-Milwaukee Field Station, Ozaukee County, Wisconsin (43°22′ N, 88°02′ W). The study site was located in a mature, upland forest dominated by Sugar Maple (*Acer saccharum*), White Ash (*Fraxinus americana*), American Beech (*Fagus grandifolia*), Hophornbeam (*Ostrya virginiana*), and Shagbark Hickory. Artificial nest-boxes (12 x 12 x 12 cm with 2.5 cm opening on one side) were placed 1 to 2 m high on the nearest tree to a grid point in a 9 by 9 grid with 10 m between grid points (0.64 ha area). Wood chips and sawdust were provided in each box for bedding. Nest-boxes were placed at the site the week of 18 October 1987 and were first checked the week of 1 November 1987.

On 17 and 30 November 1987, 15 and 29 December 1987, 12 January 1988, 16 February 1988 and 11 March 1988, the number of nuts in each box was counted, as well as the number of nuts that were at least one quarter consumed. Boxes were checked on additional days for their use as day refuges, but counts of nuts were not made on these days. A nest-box was considered to be a food storage site if two or more nuts were found in it, during at least one check. A nest-box was considered to be a day refuge site if at least one mouse was captured in it. Day refuge sites could also be distinguished because of the nesting material (leaves) added by the mice. All nest-boxes showed signs that they had at least been explored (i.e. the presence of feces).

Results

The mice used 21 nest-boxes as day refuges. Thirty-nine boxes were used as food storage sites. In only two cases were nest-boxes used for both day refuges and food storage sites, indicating an almost complete separation of these two uses. A comparison of tree species and tree size (DBH) indicated no significant differences between day refuge sites and food storage sites.

Both the number of nest-boxes used for food-storage and the mean number of nuts per box

TABLE 1. Number of nest-boxes used for food-storage, mean number of hickory nuts per nest-box, and percentage of hickory nuts partially consumed on each date.

	17 Nov.	30 Nov.	15 Dec.	29 Dec.	12 Jan.	16 Feb.	17 March
Number of boxes	16	20	32	39	39	39	39
Mean number of nuts	3.2	4.8	4.9	5.1	4.8	4.4	4.2
Percent consumed	9.8	17.2	34.5	48.2	62.1	83.2	92.1

increased from mid-November to the end of December (Table 1). From January on, the number of boxes used for food-storage remained constant, while the mean number of nuts per box decreased slightly. The percent of hickory nuts that were partially consumed remained low until mid-December and then steadily increased after that (Table 1).

Discussion

The artificial nest-boxes were used both for day refuges and for food storage. A single nest-box, however, was rarely used for both food storage and as a day refuge. The reasons for this separation are unclear, but it has been reported before previously in a laboratory study (Tadlock and Klein 1979). As day refuge boxes were frequently used by more than one individual, using separate boxes for food storage may have allowed individuals to defend these food sites, but still nest communally. Communal nesting may be important during winter because of the energetic advantages of huddling (Glaser and Lustick 1975).

The mice appeared to stop caching hickory nuts by the end of December. Food caching among *P. leucopus* has been reported to be influenced by both temperature and day length (Barry 1976). The period of food-storage found in this study corresponds to a period of decreasing day-length and decreasing temperatures. The stoppage in food-storage at the end of December could be related to either the change to increasing day-length or because the presence of snow cover beginning late in December made the location of nuts difficult. The hickory nuts appeared to be used throughout the winter and may have been an important source of food.

Acknowledgments

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Albinism in a Wild Population of the White-footed Mouse, *Peromyscus leucopus*

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Sloan, Ronald J., and Harvey R. Smith. 1989. Albinism in a wild population of the White-footed Mouse, *Peromyscus leucopus*. Canadian Field–Naturalist 103(3): 411–414.

A relatively high incidence of albinism in a managed population of White-footed Mice (*Peromyscus leucopus*) was observed in a study area near Branford, Connecticut. The estimated apparent mutation rate of 1.6×10^{-3} is high compared to published observed rates of $< 10^{-6}$. This may have been due to relaxed natural selection as a consequence of management activities (artificial feeding and provision of nest boxes) coupled with a potential for increased inbreeding as reflected by a low effective population size (N_e) of 12.8 mice.

Key Words: Albinism, mutation rate, White-footed Mouse, *Peromyscus leucopus*, selection, management.

Effective population size, or "genetic neighborhood" (N_e), is important in the maintenance of heterozygosity in the wild (Crow and Kimura 1970). In a three-year study to ascertain the feasibility of managing White-footed mice (*Peromyscus leucopus*) as part of an integrated control measure of Gypsy Moth (*Lymantria dispar*), a low effective population size (N_e) of 12.8 mice was determined (Smith and Sloan 1988). During the course of the project, several instances of albinism were also observed. This paper discusses the relatively high frequency of albinism to management efforts and (N_e).

The study involved three sites situated in a 65- to 85-year-old stand of mixed hardwoods on the Lake Saltonstall Reservoir watershed, Branford, Connecticut (approximately 41° 15′ N, 73° 10′ E) (Smith 1975; Smith and Lautenschlager 1981). Site one (3.3 ha) was 2 km south of site two (3.3 ha). Site three (2.5 ha) was 230 m south of site one.

In June 1973, a grid of 144 Sherman live-traps was established on sites one and two with 15 m intervals between stations. In June 1975, a grid of 126 live-traps was established in plot three (same spacing). A five-day sample was taken monthly (except December through February). In addition, nest boxes based on the design of Nicholson (1941) were wired in place from ground level to 2 m in height. The nest boxes, which were considered part of a management plan (along with supplemental feeding stations), provided additional sample data, particularly of the nestlings. Sites one and two had 72 nest boxes spaced evenly in two quarter sections of each site. In site three, 35 nest boxes were uniformly spaced.

Nest boxes were examined semi-monthly. *Peromyscus* densities (minimum number known alive) were determined by combining the sample and nest box data. At each capture, the animal's number (identified by toe-clipping), sex, age (juvenile, subadult or adult, on the basis of pelage), general condition and trap station or nest box number were recorded. Supplemental food was provided weekly at feeding stations in sites one and three from 1 October through 30 April each winter.

Two albinos were observed among 612 nestlings in artificial nest boxes across all three sites and a third subadult albino was live-trapped. All were males and corresponded phenotypically (Figure 1) to the description by Castle (1912). Sumner (1932) diagnosed albinism in *P. maniculatus* as a simple mendelian recessive trait. Laboratory breeding of our adult male is consistent with such a hypothesis. The male sired four nonalbino offspring. Another albino male captured independently of this study near Eastford, Connecticut, 56 miles from the study area, sired seven nonalbino offspring from two laboratory matings. Combining offspring of these matings, the probability of dominant, single locus albinism is $(1/2)^{11} = 0.00049$.

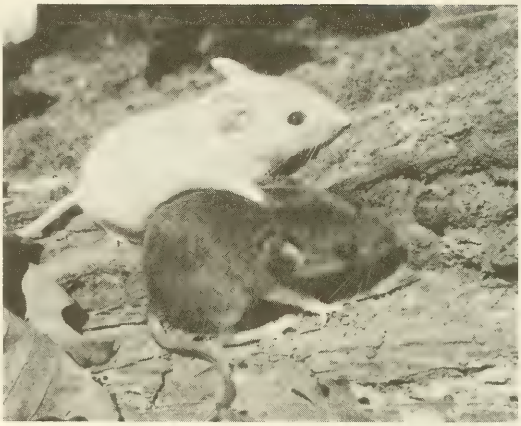

FIGURE 1. One of two male albino phenotypes observed as a nestling during the study is shown with littermate of normal pigmentation. Age is approximately 28 days.

Both of the nestling albinos occurred in site one, which was provided with supplemental food and nest boxes. They were separated by 30 m, and are of known relationship (Figure 2). The third albino was collected in adjacent site three, 362 m from the nearest observed nestling albino. His unknown relationship and age indicate that he probably was a dispersing individual.

The recessive albino phenotype can be considered deleterious; we did not observe an adult albino, nor have other studies in natural populations of the genus *Peromyscus*. If the fitness of the albino phenotype is considered negligible, the maintenance of the recessive allele must be attributed to recurrent mutation. Estimates of recessive gene frequencies (q) and of recurrent mutation rates involve randomly sampled individuals from a large panmictic population. If R equals the frequency of observed recessives from a single age class, then $q = \sqrt{R}$ or, in the case of our data, $q = \sqrt{2/612} = 0.057$. The recurrent mutation rate (μ) for a deleterious recessive allele when the genotypic frequencies are sampled near birth is $\mu = R$ or, in the case of our observations, $\mu = 3.3 \times 10^{-3}$. In this calculation we assumed for simplicity, lacking further data, that the population was in Hardy-Weinberg equilibrium, there was a neutral effect on heterozygotes, and selection against the albino gene was total (Crow and Kimura 1970; Wilson and Bossert 1970).

However, in subdivided populations, as reflected by our study plots, or in a large continuous population with restricted genetic neighborhoods, such estimates are subject to considerable error related to neighborhood frequency variance, the mosaic pattern of occurrence, the intergenerational sampling changes, and the highly skewed distribution of a

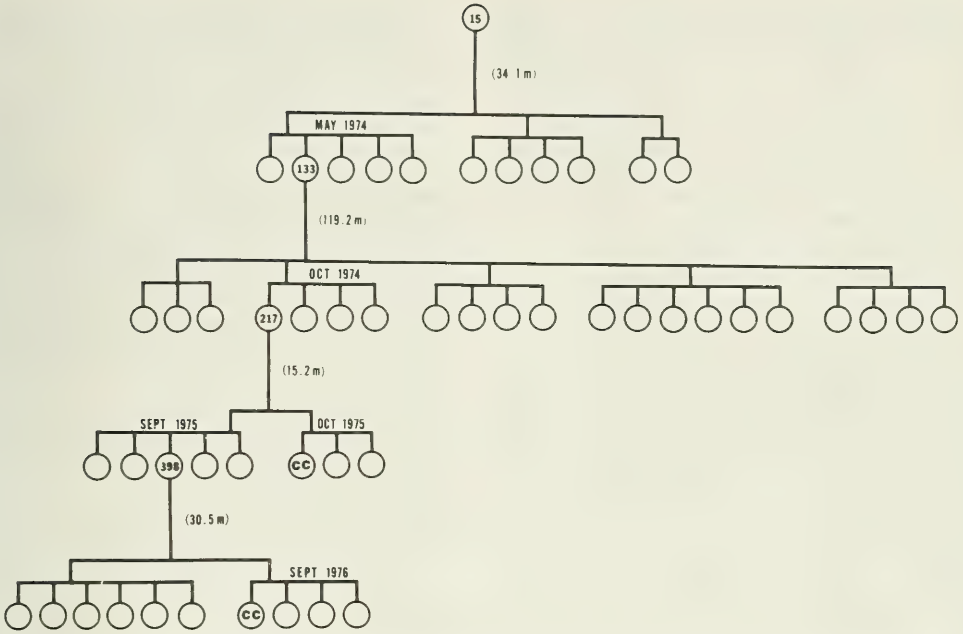

FIGURE 2. Familial relationships for the two nestling albinos (*cc*) as traced through lineage to adult females. Estimated distance from place of birth to parturition (shown in parentheses) is based on the nest box observations. Reproduction record for each female is shown chronologically from left to right.

deleterious recessive gene in populations of small effective size (Crow and Kimura 1970).

Figure 2 shows that the two albino phenotypes were not independent mutation events. Although inbreeding was not observed, a direct familial relationship between the two albinos may further suggest a relaxation of natural selection. However, it should be realized that even though our sample size was relatively large for a study of this type, an estimate of μ based on one albino would still be inflated, or 1.6×10^{-3}. Hence, one must consider the influence of a small effective population size, or "genetic neighborhood" (N_e). Reed et al. (1986) showed that small effective population sizes increased the inbreeding coefficient as a function of the number of generations. Therefore, a reduced or restricted breeding population with multiparous generational reproductive patterns such as those common in *P. leucopus* may be at particular risk for fixation and genetic drift. As a consequence, observations on the frequency of albinos in a managed population are higher than would be expected in unmanaged situations.

The specific effects of management (supplemental feed and provision of nest boxes) on the *P. leucopus* population, particularly density, were described by Smith (1975) and Smith and Lautenschlager (1981). Nest boxes resulted in a positive effect on mouse density, but the effect was not significant (X^2, $P < 0.05$). The average density increased from 9.6 mice per ha to 9.8 mice per ha in the spring and from 16.1 mice per ha to 20.2 mice per ha for the fall in control areas versus nest box plots. Conversely, supplemental feed, in both the feed-only and feed-plus-nest box plot did significantly (X^2, $P > 0.005$) increase mouse density. These densities compared to the control values noted above, were 16.5 mice per ha and 28.6 mice per ha, spring and fall, respectively, for supplemental feeding only, and 15.5 mice per ha in the spring and 34.7 mice per ha in the fall for feed-plus-nest boxes. Increased dispersal as a consequence of the higher population density in site one, caused by supplemental food, may have introduced the gene into site three. Our densities of adult *P. leucopus*, subsequent to supplemental feeding, are considerably higher than the average estimated population density of 9.6/ha (March-November, 1964-1967, all ages) based on data from Miller and Getz (1977) for this species in a deciduous upland habitat in Connecticut. Even without increased densities and presumably increased dispersals, movement over the 267 m between sites one and three would not be unusual (Blair 1953; Stickel 1968). The gene, however, may not have occurred in site two (nest box only) because of the much greater distance (2 km) involved. Because our study originally was designed to determine the feasibility of managing *P. leucopus*, mouse management activities may have relaxed natural selection, contributing to the apparent high rate of mutation. Most mutations of this type occur nearer the rate of 10^{-5} (Wilson and Bossert 1970; Srb and Owen 1952), or even less at 10^{-6} or 10^{-8} (Cavalli-Sforza and Bodmer 1971). Schlager and Dickie (1966) estimated a spontaneous mutation rate for the albino (c) allele in the laboratory mouse at 9.7×10^{-6}.

Herein, due to the management activities and a low effective population size, we recognize serious pitfalls associated with a simplistic approach in deriving mutation rates such as an assumed Hardy-Weinberg equilibrium between mutation and selection and lack of inbreeding which may have occurred (see Figure 2), and unknown fitness (Cavalli-Sforza and Bodmer 1971). It is obvious, however, that we have relaxed the forces of selection but not the mutation rate. Therefore, we caution against application of mutation rate calculations without considering potentially unknown factors involved in their derivation. Therefore, in discounting the veracity of our "apparent" mutation rate and given the lack of published data on "wild" populations of the type discussed, we feel this report has practical bearing on the effect of manipulating environments on subsequent genetic structure in free-living populations.

Acknowledgments

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First Specimen Record of the Indigo Bunting, *Passerina cyanea*, in British Columbia

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Young, Bruce E. 1989. First specimen record of the Indigo Bunting, *Passerina cyanea*, in British Columbia. Canadian Field-Naturalist 103(3): 415.

A specimen originally identified as a Lazuli Bunting (*Passerina amoena*) collected on 1 November 1953 in Port Hardy, Vancouver Island, was recently re-identified as an Indigo Bunting (*Passerina cyanea*). This represents the first British Columbia specimen record and an unusually late fall occurrence of the species north of its wintering ground.

Key Words: Indigo Bunting, *Passerina cyanea*, Vancouver Island, British Columbia.

While at the Yale Peabody Museum (YPM) in New Haven, Connecticut, to study the pattern of molt in the Lazuli Bunting (*P. amoena*), I came across specimen YPM 72124, labeled as a Lazuli Bunting. The bird was collected by Kenneth Racey (field number 104) on 1 November 1953 at Port Hardy (50°41′N, 127°30′W), northern Vancouver Island, British Columbia. It was sexed as a male, with "clear" (i.e., unossified) skull, total length of 145 mm and wing length 65 mm. The stomach contained insects.

Upon exmaination, it was obvious because of the coloring of its ventral contour feathers that the bird was a hatching-year Indigo Bunting, *P. cyanea*, in its first basic plumage (Rohwer 1986). The throat was mottled gray and dingy white, blending into a mottled gray and dark olive-buff on the breast and belly. Hatching year Lazuli Buntings have a light throat, buffy cinnamon breast, and light belly, sometimes with dark streaks along the belly feather shafts. Despite having looked at over 200 hatching year Lazuli Bunting specimens, I have never seen a hint of olive or such uniform coloration of the breast and belly as is displayed in this specimen and is common in young Indigo Buntings (Godfrey 1986; S. Rohwer, University of Washington, personal communication). Otherwise, the specimen has a uniform ruddy brown crown, back, and rump. The wings are dark brown with poorly distinguished dark buff wing bars. Hatching-year Lazuli Buntings, by contrast, have much more distinct wing bars. Otherwise, the tail is a uniform dark brown, indistinguishable from that of a Lazuli.

Godfrey (1966) listed the earliest known British Columbia record of Indigo Buntings as a sighting at Trail in 1958 by a man variously cited as Sam H. Hopkins (Cannings 1974) or as the late Sam Sopkinson (Street and Merilees 1974). I am aware of nine more recent sight and photographic records in B.C. (summarized by Cannings 1974; Roberson 1980; Godfrey 1986). Nine of these ten records were in the summer, late May through July (Roberson 1980), with only a single autumn record on 1 September 1977 at Golden (Rogers 1978).

The Yale Peabody Museum specimen 72124 is the earliest known record of the Indigo Bunting in B.C., and, as far as I can tell, the only Indigo Bunting specimen from the province (R. W. Campbell, personal communication). Furthermore, it is only the second, and by far the latest, autumn record for the species. The 1 November date would be unusually late anywhere north of the winter range of the species; latest migration dates from across northern North America are typically in early October. Finally, YPM 72124 is the first Vancouver Island record. This also would have been a surprising occurrence for a Lazuli Bunting, but it was not reported as such in the literature at the time.

No doubt other important mislabeled specimens lie in museum cabinets awaiting examination by trained eyes.

Acknowledgments

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The Rock Wren, *Salpinctes obsoletus*, Breeding at Churchill, Manitoba

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Seutin, Gilles, and Bonnie Chartier. 1989. The Rock Wren, *Salpinctes obsoletus*, breeding at Churchill, Manitoba. Canadian Field-Naturalist 103(3): 416–417.

During the summer of 1988, a pair of Rock Wrens bred near Churchill, Manitoba, some 1000 km N of the normal breeding range of the species. Five young hatched, but at least three died before fledging. Possible explanations for the presence of these wrens in Churchill are their natural tendency to wander, accidental transportation in railroad boxcars, and the drought in the Prairies that summer.

Key Words: Rock Wren, *Salpinctes obsoletus*, Manitoba, breeding.

The Rock Wren (*Salpinctes obsoletus*) is a relatively common breeder in most of the western United States, in Mexico, and in Central America south to northwestern Costa Rica (A.O.U. 1983). In Canada, it is restricted to the southern part of British Columbia, Alberta, and Saskatchewan (Godfrey 1986). During the summer of 1988, a pair of Rock Wrens was found breeding near Churchill, Manitoba (58°45′N; 94°05′W), some 1000 km N of their normal range.

On 28 June 1988, a Rock Wren was found singing 5.5 km E of Churchill. The bird was frequently singing, making itself conspicuous to any observer, and, because the site is regularly checked by birdwatchers in the summer, it is unlikely that this wren arrived in Churchill much before late June. The bird was observed foraging among, and perching on, concrete blocks of diverse shapes and sizes that make up an embankment 1 — 2.5 m high by 200 m long. The wren was seen gleaning small insects from small Balsam Poplars (*Populus balsamifera*) and willow shrubs (*Salix* spp.) growing among the blocks. The numerous spruce trees growing at the bottom of the embankment were never used for foraging or perching. On 4 July, G.S. confirmed earlier reports of the presence of two individuals. At 10:00, a bird was seen carrying a white feather, closely followed by a second individual. An hour later, the pair was observed again with the trailing bird carrying a large, green unidentified caterpillar (about 15 x 4 mm).

On 27 July, G.S. saw both birds carrying insects in their bills and after 20 min of observation found the nest in a cavity under a large concrete slab. The entrance of the cavity was somewhat triangular, about 15 cm at the base and 8 cm high. The cavity was about 30 cm deep and was lined with small stones as is typical for the species but there was no lined approach to it as is sometimes the case (Harrison 1978). The nest, a thin cup of fine plant fibers lined with hairs and a few feathers, was 20 cm from the opening. Three nestlings were visible, but there may have been more. All had closed eyes and were almost entirely naked. When the nest was visited on 1 August, five nestlings were found and banded. They all had open eyes and showed extensive growth of down and flight feathers.

On 29 July, the adults were trapped using mist nets and banded with standard U.S. Fish and Wildlife Service aluminum bands. Plumages of both birds were moderately worn and showed no sign of molt. One bird had an extensive brood patch and was assumed to be a female. The second bird lacked a brood patch but showed no cloacal protuberance either; it was assumed to be a male. External measurements (wing chord, tail, tarsus, culmen and hallux lengths) did not differ statistically from samples of Canadian specimens housed in the National Museum of Canada collection (original data available from G.S.; *t*-test contrasting a single observation with a sample mean, Sokal and Rohlf 1981; $P > 0.05$ in each case). Because Rock Wrens show little morphometric variation throughout their North American range, these measurements are not informative about the origin of the Churchill birds.

On 7 August, 52 mm of rain fell on Churchill during a major thunderstorm. Strong winds, reaching 60 km/h lasted for several hours, and the lowest maximum (11.7°C) and minimum (4.5°C) daily temperatures for the first half of the month were recorded (Environment Canada 1988). That evening, B.C. found three dead young in the nest and no sign of the other birds. During the following weeks, the area was checked a few times by different persons, but no wrens were seen.

There is at least one previous record of the Rock Wren in Churchill. A pair, presumably breeding, was observed in 1956 carrying food near a pile of old timbers, and "on 3 August the bird [one of them] appeared to be in a state of great anxiety at

Beckett's approach, but no young were found" (Crosby and Beckett 1957). No birds were seen later that year, so breeding was never confirmed. Two wrens, possibly the same individuals, were observed the following spring in Churchill, but they were seen only once (Jehl and Smith 1970). There are two other summer reports of Rock Wrens seen far north of their normal breeding range (Stanton, northwestern Mackenzie, and Fort Chipewyan, northern Alberta; Godfrey 1986); both involve sightings of single birds.

The Rock Wren is also a casual vagrant in the eastern United States during migrations and winter (A.O.U. 1983). It was suggested that many of the eastern records pertain to individuals transported accidentally in railroad boxcars (A.O.U. 1983). This is a plausible explanation for the occurrence of Rock Wrens in Churchill, the northern end point of the Manitoban railroad network. Alternatively, the severe drought in the Prairies during the summer of 1988 may have prompted the wrens to wander. The Rock Wren is only one of many typical prairie birds that reached the Churchill region during the summer of 1988. The list includes first Churchill records for the Prairie Falcon (*Falco mexicanus*), Green-tailed Towhee (*Pipilo chlorurus*), Lark Sparrow (*Chondestes grammacus*), and Lark Bunting (*Calamospiza melanochorys*), as well as observations of several species that have previously been reported less than ten times in the region (*see* Chartier 1988): the Mourning Dove (*Zenaida macroura*), Western Kingbird (*Tyrannus verticalis*), Northern Mockingbird (*Mimus polyglottos*), Le Conte's Sparrow (*Ammodramus leconteii*), and Nelson's Sharp-tailed Sparrow (*A. caudacutus nelsoni*).

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Observation of a Female Moose, *Alces alces*, Accompanied by Possible Quadruplet Calves at Isle Royale National Park, Michigan

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A female Moose (*Alces alces*) with possible quadruplet calves, observed and photographed on 4 July 1988 at Isle Royale National Park, Michigan, represents the first North American report of four calves accompanying one cow.

Key Words: Moose, *Alces alces*, quadruplets, calves, fecundity, Isle Royale, Michigan.

An observation of a female Moose (*Alces alces*) accompanied by four calves was reported to National Park Service (NPS) personnel at Isle Royale National Park, Michigan (48° N, 89° W) during the summer of 1988. The cow and calves were watched for several hours on the afternoon of 4 July by a park visitor, A. Blinkman, as they moved along an open gravel beach in a sheltered cove on Lake Superior. Inspection of a color photograph taken by A. Blinkman (in NPS files, Houghton, Michigan) shows the female moving away from the beach into shoreline vegetation with four similar-sized, month-old calves following close at heel. Regardless of whether these calves were siblings or associated as the result of one or more adoptions, this observation evidently represents the first North American field record of four calves accompanying one cow Moose.

Another park visitor, R. Boughton, observed a cow with three calves on 20 August at a site < 5 km from where the cow and four calves had been previously reported. The proximity and timing of these two observations suggest that the same cow-calf group may have been seen in both cases. Calf production in the Isle Royale Moose population has been closely monitored since 1959 (e.g. Mech 1966; Peterson 1977; Peterson and Page 1983), yet calf trios have been reported only once previously (Moll and Moll 1976) during that 30-year period.

Adult (≥ 3.5 yr) females commonly give birth to twin calves (Franzman 1981; Sæther and Haagenrud 1983), although twinning rates vary substantially along both geographical and temporal gradients. For example, Markgren (1982) noted that twinning rates varied among coastal (65% twins), low-elevation inland (39%), and foothills (17%) populations studied in Sweden. The observed twinning rate in the Isle Royale population between 1964 and 1976 ranged from 0 to 48% annually (Mech et al. 1987).

Danilov (1987) reported that triple embryos occurred in from 0.06 to 1.69% of cows examined in studies of Moose reproductive tracts conducted in the Soviet Union. Triple embryos were found in < 0.5% of 930 cows from Sweden examined by Markgren (1969). Triple ovulations occurred in > 2.0% of 140 cows from Ontario examined by Simkin (1965). Crête and Beaumont (1986) reported finding four primary corpora leutea in one reproductive tract which they examined.

Field observations of calf trios are unusual, but have been previously reported from Alaska (Hosley and Glaser 1952; Bailey and Bangs 1980; Franzmann 1981; Coady 1982), Michigan (Moll and Moll 1976), Newfoundland (Pimlott 1959), Ontario (Peterson 1955), and Sweden (Skuncke 1949; Markgren 1968). I have found only one previous field record of possible quadruplets in the literature — an autumn observation of a cow accompanied by four calves in Sweden (Skuncke 1949).

Observations of multiple young in the field do not necessarily imply that all were born to the same cow, but the tendency of female Moose to adopt orphaned or abandoned calves is very poorly understood and has not been well documented in the literature. R. O. Peterson (personal communication) reported witnessing the adoption of a radio-collared calf by another cow after the mother was immobilized briefly during a study of calf mortality conducted on the Kenai Peninsula, Alaska, in 1977.

Forage quality and severity of previous winters are both important determinants of maternal nutritional status and fecundity in Moose (Markgren 1969; Franzmann and Schwartz 1985; Mech et al. 1987); however, predation has been documented as the predominant cause of neonatal calf mortality (Wolfe 1977; Franzmann et al. 1980; Ballard et al. 1981; Gasaway et al. 1983; Messier and Crête 1985). Numbers of the only Moose predator present at Isle Royale, the Gray Wolf (*Canis lupus*), declined from 50 to 12 individuals since 1980, reaching a 30-year low in 1988 (R. O. Peterson, personal communication). Under such circumstances, reduced predation pressure might be expected to lead to increased neonatal calf survival and could result in a greater number of field observations of cows accompanied by multiple young.

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Muskrat, *Ondatra zibethicus*, Population Responses to Harvest on the Old Crow Flats, Yukon Territory

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Simpson, Mark R., and Stan Boutin. 1989. Muskrat, *Ondatra zibethicus*, population responses to harvest on the Old Crow Flats, Yukon Territory. Canadian Field-Naturalist 103(3): 420–422.

Population responses to harvest were investigated in Muskrats (*Ondatra zibethicus*) on the Old Crow Flats, Yukon Territory. The hypotheses of compensatory reproduction, precocial breeding and increased survival as mechanisms of recovering from high mortality in northern Muskrat populations were not supported. However, more immigrants were captured on trapped than untrapped areas, supporting the hypothesis that dispersal into trapped areas is a mechanism by which Muskrat populations may recover from high mortality induced by trapping. Time constraints on reproduction in northern environments may limit the number of mechanisms by which populations are able to recover from trapping.

Key Words: Muskrats, *Ondatra zibethicus*, harvest, immigration, reproduction, survival, Yukon Territory.

Despite the obvious ecological, economic and social importance of Muskrat (*Ondatra zibethicus*) trapping, few studies have examined the effects of harvest on the population dynamics of this species (Smith et al. 1981; Parker and Maxwell 1984; Clark 1987), and none has examined these in northern populations. It is believed that 50 to 75% of muskrats in an area can be removed in the fall without deleterious effects on the population (Dozier 1948; Alexander 1955; Smith et al. 1981). The ability of Muskrat populations to compensate for such heavy losses has been attributed to four possible mechanisms: increased precocial breeding (Parker and Maxwell 1984), increased litter size or compensatory reproduction (Olsen 1959), improved survival of the remaining individuals (Errington 1963; Clark 1987), or increased immigration into areas of low density (Errington 1940). Our aim was to determine if any of the above mechanisms operate in a northern Muskrat population.

Methods

Four study sites were selected in 1985 on the Old Crow Flats, Yukon Territory (68°05′ N, 140° 05′ W). Muskrats on two experimental sites were removed by trapping during May and June to simulate the native harvest, while two control sites were not harvested. Each trapped area was within 1 km of an untrapped area, and all areas were located within a 10-km radius.

All areas were initially livetrapped using Tomahawk livetraps (15.2 × 15.2 × 45.7 cm) to enumerate the populations. Only one control and one experimental area were trapped at any one time. Livetrapping began in April 1985 and early May 1986 and continued until 15 June of each year. It then resumed in late July and continued until September. Livetrapping was suspended on both experimental areas while removals were in progress (see below). Each livetrapping session ended when at least 70% of the animals caught that day had been previously trapped during the same session.

During the ice-free period (June to September), livetraps were placed on feeding sites along the shore of the lakes and in the vicinity of burrow openings. During the period of ice cover (April to May), traps were placed at feeding sites within pushups and were covered with snow (Stevens 1953). Traps were checked at 8-hour intervals. Captured animals were marked with a numbered #1 monel ear tag (National Band and Tag Company, Newport, Kentucky), weighed with a Pesola spring scale, sexed, aged by pelage characteristics, and then released.

Reproductive condition was assessed for males by testes position and recorded as scrotal or abdominal. Female status was recorded as lactating/nonlactating and perforate/nonperforate vagina. Pelage colour distinguished adult (brown) and juvenile (gray) age classes. An index of immigration was calculated by dividing the number of new adults captured (adults not enumerated previously) by the area (ha) of the study site.

Muskrats were removed from the two experimental areas during May and June of 1985 and 1986 by trapping at pushups with #1 Victor longspring trap and by shooting. According to the information obtained from livetrapping, at least 50% of the resident animals were removed from both areas. The tag number and age of each harvested animal were recorded. Sex and reproductive condition were also recorded, as well as the number of embryos or placental scars present in females.

The number of scars/female and the number of young livetrapped/adult females were used as measures of productivity. Minimum values of overwinter survival were calculated by comparing the proportion of ear-tagged individuals captured in 1985 that were retrapped in 1986. This is a minimum estimate since it does not account for individuals that may have lost their tags, dispersed from the site, or escaped further capture. Unless otherwise indicated all values are presented as means ± 1 SD.

TABLE 1. Number of new adults (captured for first time), immigration index (new adults/size of area), and overwinter survival for harvested and unharvested areas on Old Crow Flats, Yukon Territory

	# New Adults	Area (ha)	Immigration Index	Overwinter Survival
Harvested	20	12.50	1.60	12.96%
(experimental)	18	10.78	1.67	21.60%
Unharvested	10	13.30	0.75	43.30%
(control)	3	9.00	0.33	35.30%

Results

None of the 384 juveniles livetrapped in 1985 and 1986 had reproduced as indicated by reproductive condition, nor did any female juveniles, removed in spring from experimental areas, have placental scars. There was no significant difference between the mean adult placental scar counts on experimental (9.2 ± 2.2) and control areas (7.7 ± 2.4; $t = 0.433$, $P = 0.668$). However, more new adults were tagged on experimental than control areas (Table 1). The difference between immigration indices of the two control areas (0.75 and 0.33) and the two experimental areas (1.6 and 1.7) was significant ($t = 5.143$, $P = 0.036$; Table 1). There was no significant difference in overwinter survival between the experimental sites ($P = 0.068$), or between the control sites ($P = 0.156$). However, overwinter survival was significantly greater on control areas than on experimental areas ($P < 0.001$; Table 1).

Discussion

Precocial breeding, compensatory reproduction, and increased survival were not found in harvested Muskrat populations on Old Crow Flats. However, more Muskrats moved into harvested areas than control areas, suggesting that immigration is a mechanism of population recovery in northern areas.

Precocial breeding has been frequently reported in Muskrat populations. Parker and Maxwell (1984) noted that precocial breeding occurred in 5% of juveniles sampled in a New Brunswick marsh. Similarly, Errington (1963) reported levels of precocial breeding in Iowa Muskrats of 5.3%. However, our findings agree with Smith et al. (1981), who did not detect precocial breeding in the Quinnipiac estuary near New Haven, Connecticut. At present, the existence of precocial breeding in more northerly Muskrat populations is questionable (Moses and Boutin 1986).

Increases in Muskrat litter size or in number of litters related to decreases in population density have been reported by Errington (1951) and by Olsen (1959). Compensatory reproduction has been proposed as a major mechanism of population regulation in Muskrats. However, there was no significant difference in litter size between experimental and control areas for the Old Crow population. Similar results were found by Parker and Maxwell (1984) in New Brunswick. Note that annual production per female is significantly lower on Old Crow Flats (one litter) than in more southern populations of Muskrats, where two or three litters per year are usually produced (Simpson 1987).

This may indicate that although compensatory reproduction may be a mechanism for population maintenance in southern populations of Muskrats, the constraints imposed by a short reproductive season make it an unlikely strategy in northern environments. Observations of northern populations of Beavers (*Castor canadensis*) support the hypothesis of seasonal constraints on reproduction. While Boyce (1974) observed no significant difference in litter size between trapped and untrapped populations of Alaskan Beaver populations, Nordstrom (1972) noted that trapped Beaver populations had significantly larger litters in New Brunswick.

According to the survival hypothesis, survival rates on harvested areas are expected to be greater than on unharvested areas (Errington 1963). Reduced overwinter survival observed on trapped areas in this study may indicate that a minimum population density is required to ensure overwinter survival. MacArthur (1978) found that access to winter forage was dependent upon the maintenance of active pushups. This, in turn, was facilitated by frequent use of the pushups by Muskrats feeding on a rotational basis. Lower densities may therefore reduce winter foraging ability by limiting the number of open plunge holes. Lower densities may also affect the lodge microclimate, thereby increasing maintenance energy requirements.

As suggested by Errington (1940), immigration into areas of reduced density may compensate for trapping mortality. The appearance of new adults in harvested areas after spring dispersal (Errington 1940) allows for repopulation of these areas without altering the reproductive schedules of resident animals. Mathiak and Linde (1954) found that immigration was unimportant in repopulation of Muskrat vacant habitat on Horicon Marsh in Wisconsin. Their study showed that less than one percent of tagged refuge individuals moved outside their area of capture.

However, Parker and Maxwell (1984) estimated that 20% of the spring population emigrated from trapped impoundments in New Brunswick. Similarly, the significantly higher influx of adult Muskrats into the trapped areas of the present study indicates that spring dispersal may be of substantial benefit to regions of reduced density. This could be especially important in areas where the short growing season precludes production of multiple litters or precocial breeding. The lower immigration observed in untrapped areas may be a density-dependent response, whereby high densities of established residents may block normal dispersal movements into those areas.

In summary, immigration appears to be a mechanism by which areas of low density can be repopulated in northern environments. Seasonal time constraints probably preclude the occurrence of compensatory and precocial reproduction in these environments.

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American Marten, *Martes americana*, Home Ranges in Grand Teton National Park, Wyoming

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Home ranges of 27 male and 18 female American Martens in Grand Teton National Park, Wyoming, were examined from April 1975 through April 1979. Live-trapping (N = 45 martens) and radio-telemetry (N = 4 martens) data were used in SPACE-OUT, a computer analysis program to calculate home ranges and geometric centers. Male ranges averaged 2.33 km^2 (sd = 2.03, range 0.02-6.63) and female ranges 1.10 km^2 (sd = 0.83, range 0.10-3.82). Home range size was directly and significantly related to number of "captures" (both traps and telemetry locations, N = 493 total). Spatial over lap was extensive within and between the sexes, but males overlapped little temporally. For one male, trap data (N = 96 locations) showed a home range of 8.08 km^2 and telemetry data (N = 27 locations) showed 6.63 km^2. Resident male (N = 15) ranges averaged 3.74 km^2, while those of non-resident males (N = 12) averaged 0.56 km^2. No seasonal differences in ranges were found. The martens studied showed spatial use patterns similar to that found for martens elsewhere.

Key Words: American Marten, *Martes americana*, home ranges, Jackson Hole, Wyoming.

American Martens, *Martes americana*, are small carnivores inhabiting a variety of forest types in northern coterminous United States and throughout Canada and Alaska (for review *see* Strickland et al. 1982; Clark et al. 1987; Strickland and Douglas 1987). We studied marten home ranges in Grand Teton National Park, Wyoming, from April 1975 through April 1979. The species is abundant in northwest Wyoming (Clark and Stromberg 1987).

Our study area was a large forested "bench" on the east slope of the Teton Mountain Range between White Grass Ranch and Beaver Creek, north and west of Moose, Teton County, Wyoming (elevation about 2000 m). The site was largely subalpine Alpine Fir-Elk Sedge (*Abies lasiocarpa-Carex geyeri*) habitat type (Steele et al. 1977). Climate is characterized by low mean annual temperatures and long cold winters with thick snow cover. Mean annual temperature is 2.7° C (range: -37° C to +30° C). Snow fall averages 49.8 cm per year (about 70% of mean annual precipitation [54.3 cm]).

Methods

Data were largely obtained by live-trapping American Marten in Tomahawk traps (#202), although some information also came from radiotelemetry. Traps were spaced at 200 to 600 m and checked daily. Three permanent trap lines, 2 to 3 km apart, with 10 to 12 traps each, were operated for 7 to 10 days monthly. Temporary traplines with 3 to 10 traps each were placed between permanent lines and operated for 7 to 14 days at irregular intervals. Total area trapped was about 15 km^2. Telemetered animals were first immobilized with Sernylan and Sparine following Seal et al. (1970). An AVM Instrument Company transmitter collar (SB2-IV) was fitted and monitored. Home ranges were examined for 27 males and 18 females.

Home range analysis by means of the convex polygon method was performed with a package of programs called SPACE-OUT (Bekoff et al. 1982). The geometric center for each marten's home range was calculated (x,y coordinate) and home range was defined by 95% of the total number of locations that fell closest to these coordinates.

Results and Discussion

Male home ranges ($\bar{x}$ = 2.33 km^3, standard deviation [SD] = 2.03, range 0.02-6.63) were larger than those of females ($\bar{x}$ = 1.10 km^2, SD = 0.83, range 0.10-3.82), but the difference between the sexes was not statistically significant (F = 2.37, p = 0.06). Similar home range sizes for males and females were found elsewhere (Hawley and Newby 1957; Francis and Stephenson 1972; Soutiere 1978; Campbell 1979; Burnett 1981; Clark 1982; Taylor and Abrey 1982). The larger estimated mean home range size for males versus females in our study may be related to there being more trap and telemetry locations for males (*see* regression analysis, below), but a comparison of males and females for whom the same number of locations was obtained indicated that males still had larger home ranges.

Regression analyses revealed that for males, there was a direct and significant relationship between numbers of captures (x) and home range estimate (y): $y = 1.330 + 0.407\ x - 0.013\ x^2 + 0.000001\ x^3$ ($F = 5.54$, $p = 0.006$, $r^2 = 0.44$). For females the relationship was not significant. Soutiere (1978) also reported that home range size was related to the number of locations, but did not provide regression analyses. Our data, used in a linear model, indicate that at least 30 to 40 locations for each individual are necessary for an accurate estimate of home range area (*see* Bekoff and Mech 1984).

Extensive spatial overlap between and within sexes was apparent, but temporal overlap was minimal for males. Campbell (1979) noted that male martens behaved territorially towards each other in nearby Bridger-Teton National Forest whereas females seemed to tolerate other females and males. Hawley and Newby (1957) and Francis and Stephenson (1972) found overlap between male and female home ranges, but animals of the same sex excluded one another.

Trapping and telemetry data were compared for one male for whom sufficient data existed (over 1364 days, 1 June 1975 to 27 March 1979). Trapping resulted in a home range of 8.08 km^2 ($N = 96$ locations) whereas telemetric data indicated a home range estimate of 6.63 km^2 ($N = 27$ locations). The mean distance between successive locations for trapping and telemetry were 1.12 km ($SD = 1.0$) and 1.66 km ($SD = 1.36$), respectively. The difference between these two data sets may be the result of the larger sample size for trapping or the placement of traps at set locations. Marten had to be trapped to register a point of occupancy (which is not so for telemetry data). There are no available data with which to compare these results.

Home range estimates for residents (on the study area for > 90 days) of both sexes ($N = 20$ martens and 418 locations) were significantly larger ($\bar{x} = 3.74$, $SD = 2.05$) than those for non-residents (on study area for 8-90 days) of both sexes ($N = 25$ martens and 75 locations; $\bar{x} = 0.56$, $SD = 0.61$; $F = 13.271$, $p = 0.004$). These data probably are confounded by the fact that many more locations were recorded for residents. While non-resident animals may actually have larger ranges, they may simply pass through an area and may not be as susceptible to trapping as residents (Burnett 1981).

Seasonal differences in mean home range size also were analyzed. We found no significant differences in home range estimates for males during fall (August-November; $\bar{x} = 1.59$ km^2, $SD = 1.59$), winter (December-March; $\bar{x} = 1.35$, $SD = 1.69$), or spring/summer (April-July; $\bar{x} = 2.89$, $SD = 2.42$; $F = 0.91$, $p = 0.43$). The smaller home ranges in winter may be due to restricted travel during periods when soft, thick snow was present. At other times, such as on crusted hard snow, martens can travel about easily. The increase in home range size beginning in early spring following snow melt may be due to the low density of small mammal prey. By mid-fall, martens have bred and apparently settled into a relatively stable spatial configuration which they utilize until the following spring.

We also calculated the mean distance between successive trappings of males during fall ($N = 4$ martens with 43 locations; $\bar{x} = 1.25$ km, $SD = 1.27$), winter ($N = 4$ martens with 56 locations; $\bar{x} = 0.87$ km, $SD = 0.89$), and spring/summer ($N = 6$ martens with 79 locations; $\bar{x} = 1.44$ km, $SD = 1.50$; $F = 3.74$, $p = 0.025$). The distance between successive locations during fall was statistically the same as those for winter and spring/summer, but the winter distance was significantly less than that recorded for spring/summer. The same trends were noted for females, but there were insufficient data for statistical analysis.

Conclusions

In summary, our results are generally in agreement with those of other studies. Home range estimates for males from this and other studies employing similar methods vary between about 1.6 and 3.6 km^2, whereas female home ranges vary between 0.7 and 1.1 km^2 (Strickland et al. 1982). However, Mech and Rogers (1977) reported much larger home ranges for Minnesota martens (10-20 km^2 for males and 4.3 km^2 for 1 female). Other studies employing different methods (mostly based on trap data) also report much larger home ranges for both sexes (26-65 km^2; Marshall 1942; Lensink 1954; Davis 1939; *see also* Pulliainen 1982).

The differences in home range estimates strongly indicate that detailed comparisons among different studies are possible only when data have been collected and analyzed in the same manner. The result of the regression analysis in which home range estimates were found to vary directly with the number of locations (for males) suggests that differences between studies (and even within the same study) may be due to variations in the number of times an individual is located (Bekoff and Mech 1984). Radio telemetry data better described marten movements versus fixed trap locations.

Marten space use, on an annual basis, is affected by a complex array of environmental and social factors including food availability, snow conditions, and the presence of other resident martens. Our results have several inherent management implications, such as requirements for trap spacing by government wildlife agencies. Widely spaced traps that exceed the diameter of female home ranges would selectively take more males and protect females from removal.

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Observations on the Reactions of Sea Lions, *Zalophus californianus* and *Eumetopias jubatus*, to Killer Whales, *Orcinus orca*; Evidence of "Prey" Having a "Search Image" for Predators

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Baird, Robin William, and Pam Joyce Stacey. 1989. Observations on the reactions of sea lions, *Zalophus californianus* and *Eumetopias jubatus* to Killer Whales, *Orcinus orca*; evidence of "prey" having a "search image" for predators. Canadian Field-Naturalist 103(3): 426–428.

Observations on the reactions of California Sea Lions (*Zalophus californianus*) and Steller Sea Lions *(Eumetopias jubatus)* to the presence of foraging transient Killer Whales (*Orcinus orca*) were made on three occasions. Alert and avoidance responses by sea lions were made in the presence of Killer Whales of typical appearance. In the presence of a single, foraging Killer Whale of atypical appearance, no alert or avoidance response was observed. It is possible that the sea lions did not recognize the atypical whale as a Killer Whale, suggesting that sea lions may have a perceptual "search image" for the detection of predators, based on visual cues.

On a observé en trois occasions les réactions d'otaries de Californie (*Zalophus californianus*) et d'otaries de Steller (*Eumetopias jubatus*) à la présence d'épaulards (*Orcinus orca*) en transit et en train de se nourrir. Les otaries émirent des réponses d'alerte et d'évitement quand mises en présence d'épaulards d'apparence typique, mais n'émirent aucune réponse lorsqu'en présence d'un épaulard d'apparence atypique en train de chasser. Il est possible que les otaries n'aient pas reconnu l'épaulard d'apparence atypique en tant qu'épaulard, ce qui suggère que les otaries pourraient posséder une image de recherche perceptuelle pour la détection de leur prédateurs basée sur la vision.

Key Words: Killer Whale, *Orcinus orca*, transient, California Sea Lion, *Zalophus californianus*, Steller Sea Lion, *Eumetopias jubatus*, prey, search image, foraging behaviour, Race Rocks Ecological Reserve, British Columbia.

The ability of a predator to perceive cryptic prey using a perceptual "search image" has been previously reported (e.g. Dawkins 1971). However, the concept of "prey" using a similar perceptual "search image" to detect potential predators does not appear to have been previously documented. During an ongoing study of Killer Whale (*Orcinus orca*) behaviour and ecology being undertaken around southern Vancouver Island, British Columbia, certain interactions between "transient" Killer Whales (*after* Bigg et al. 1987), California Sea Lions (*Zalophus californianus*), and Steller Sea Lions (*Eumetopias jubatus*) were noted on three occasions. These interactions suggest that sea lions may use a search image for the detection of potential predators.

Observations of interactions between transient Killer Whales and sea lions were made during 1987 at the Race Rocks Ecological Reserve (48° 18′N, 123° 32′W), a group of nine small islands approximately one mile off the southernmost tip of Vancouver Island, in the Strait of Juan de Fuca. Race Rocks is a year-round Harbour Seal (*Phoca vitulina*) colony, with seasonally abundant California Sea Lions and Steller Sea Lions (Bigg 1985). Transient Killer Whales feed primarily on marine mammals and have been observed preying on sea lions in local waters (Bigg et al. 1987). Transient Killer Whales vocalize much less than resident whales (Ford and Fisher 1982), possibly to avoid detection by mammalian prey (Morton 1987; Felleman et al. *in press*). Thus the reaction of sea lions to the presence of Killer Whales might be mediated by visual cues.

Sea lions exhibited alert and avoidance reactions to the presence of transient Killer Whales on two occasions. Vigilant behaviour, high-speed swimming away from the whales, movement into dense kelp beds and continuously lifting the upper body far out of the water were observed.

On 12 October 1987, a lone adult male transient Killer Whale of atypical appearance, photo-identified as X10 (*after* Bigg et al. 1987), was observed at Race Rocks. This individual has a dorsal fin which is bent over at its base to the left side, with the upper half dragging in the water (Figure 1). He was observed surfacing four times within three meters of approximately 150 California and Steller sea lions that were both in the water, and hauled out on small reefs. His behaviour was categorized as typical foraging behaviour as described for transient Killer Whales (Baird and Stacey 1987, 1988a; Felleman et al. *in press*). The whale moved through narrow channels between several reefs and circled a reef on which sea lions were hauled out. No noticeable reaction by the sea lions was observed.

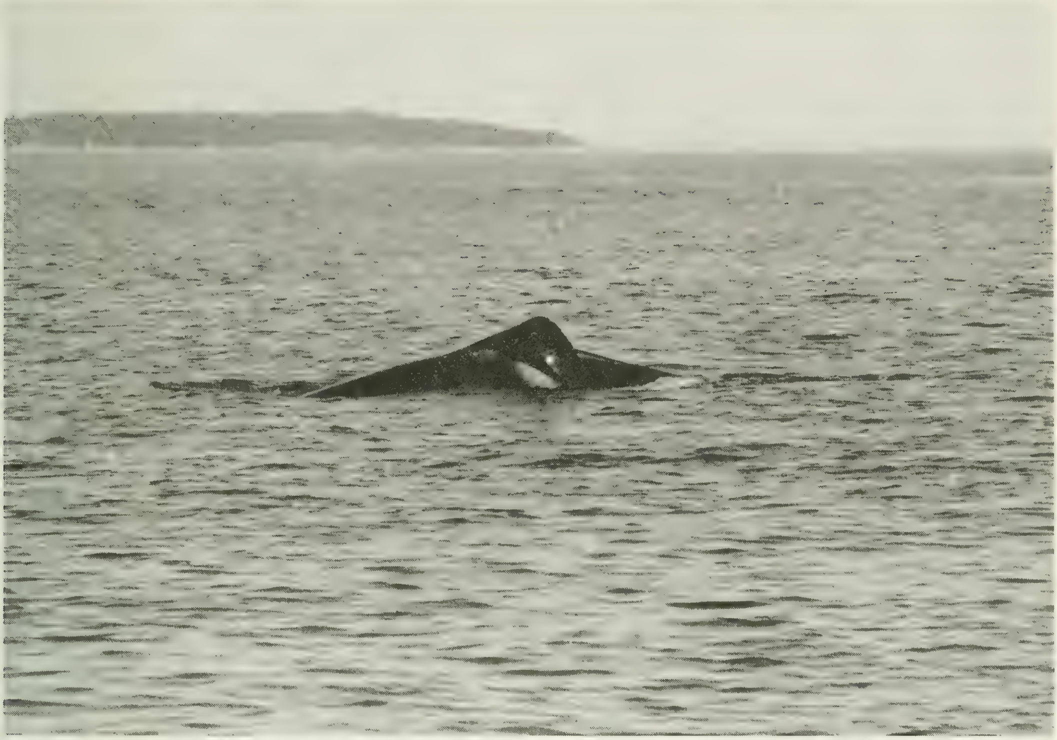

FIGURE 1. Transient Killer Whale X10 at Race Rocks, British Columbia, 12 October 1987. Photo by Robin W. Baird.

It is possible that the sea lions did not recognize the atypical whale as a Killer Whale. We suggest that sea lions respond to visual cues, such as the dorsal fin of a Killer Whale, which match a perceptual search image. Although sea lions may be formidable prey for a lone Killer Whale, lone Killer Whales have previously been observed preying on sea lions (Lopez and Lopez 1985). Recognition of a predators' behavioural state has been noted as an important factor in reaction to predators by terrestrial ungulates (Estes and Goddard 1967; Kruuk 1972; Schaller 1972). From our observation we suggest that it is unlikely the sea lions recognized the whales' behavioural state since they did not react.

As the Killer Whales in an area may be members of more than one breeding population (Bigg et al. 1987; Baird and Stacey 1988b), some of which specialize in feeding on fish, proximity of Killer Whales to other marine mammals may not always be perceived as a potential threat by the latter. Dolphin (1987) reports non-aggressive Humpback Whale (*Megaptera novaeangliae*) — Killer Whale interactions in Alaska, but unfortunately fails to mention if the Killer Whales observed were the resident type, which feed primarily on fish, or the transient type. Marine mammals have been reported in close proximity to resident Killer Whales in British Columbia, showing no apparent reaction (Jacobsen 1986). However, even in the presence of resident Killer Whales, sea lions may show interest with an increase in vigilant behaviour (Jacobsen 1986). Killer Whale attacks on marine mammals usually elicit a variety of escape responses (eg. Steltner et al. 1984; Lopez and Lopez 1985). These observations suggest that there may be a variety of cues influencing the reactions of marine mammals to Killer Whales. Further research on the perceptual processes sea lions and other similar prey species use to detect predators and on their ability to discriminate between potentially threatening transient Killer Whales and non-threatening resident Killer Whales is warranted.

Acknowledgments

We thank the following individuals: Richard Beaupied and Shari Bondy assisted with data collection; Alex Rhodes and Sea Coast Expeditions and Research provided logistical and financial support for this research; Mike Bigg, Rich Osborne, and Peter Watts provided logistical support and/or advice; Mike Bigg, Dave Duffus, Laura Kotler, Ian Moul, Linda Nichol and two anonymous reviewers made helpful comments on the manuscript; Louise Goulet, Ministry of Environment and Parks, Ecological Reserves Unit, provided permits to undertake research within the Race Rocks Ecological Reserve; and Guy Martel prepared the French-language abstract.

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Autumn Movements of Underyearling Northern Pike, *Esox lucius*, from a Large Manitoba Marsh

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Derksen, Arthur J. 1989. Autumn movements of underyearling Northern Pike, *Esox lucius*, from a large Manitoba marsh. Canadian Field-Naturalist 103(3): 429–431.

The production of Northern Pike from the Saskeram Marshes in west-central Manitoba was examined in 1983 and 1984. The outmigration of underyearling pike from the marshes occurred primarily during the autumn; that is, from late September through to freeze-up (November-December). The pattern of this fall outmigration of young pike was the same in each year. These fall movements appear to be closely related to decreasing water temperature and dissolved oxygen.

Key Words: Northern Pike, *Esox lucius*, underyearlings, migration, Saskeram Marshes, Manitoba.

Few studies have been done on the emigration of juvenile Northern Pike, *Esox lucius*, from large marsh systems. Fago (1977) reviewed the production of young pike from managed pike spawning marshes, but most of these marshes were less than 10 ha in area and the pike vacated or were drained from the marshes at an early stage. This note is based on a two-year investigation of the Saskeram Marshes (Derksen and Gillies 1985) located in west-central Manitoba. These marshes (Figure 1), which are part of the Saskatchewan River Delta, have been regulated by Ducks Unlimited since 1940 for the production of waterfowl and muskrats. At the time this study was done, water levels in the Saskeram Marshes were regulated by a stoplog dam, Bracken Dam, on the lower Birch River near its confluence with the Carrot River (Figure 1), as well as by water releases from the Cumberland Marshes upstream in Saskatchewan. A fishway, installed in Bracken Dam in 1962, allows fish access to the Saskeram Marshes. Fish, other than pike, which migrate into the marshes via the fishway include White Sucker, *Catostomus commersoni*; Walleye, *Stizostedion vitreum*; and Carp, *Cyprinus carpio*. Pike and suckers are the major species utilizing the marshes.

During the 1980-1981 winter season a major winterkill of fish involving mostly Northern Pike was witnessed in the Saskeram Marshes. Consequently, an investigation was conducted during 1983 and 1984 to determine the utilization of the Saskeram Marshes by fish and the underlying causes of winterkill events. All fish entering or leaving the marshes at Bracken Dam from spring break-up until after freeze-up were monitored on a daily basis (Derksen and Gillies 1985). This note presents results on the timing of underyearling pike movements out of the marshes.

Methods

The monitoring of fish leaving the Saskeram Marshes was started on 26 May 1983 and 24 June 1984. This monitoring was done, in part, using a spillway trap which could be fitted to the stoplogs in Bracken Dam. A description of the spillway trap is given by Derksen and Gillies (1985). In 1983, only one spillway trap was used, and in 1984 two traps were used. The additional trap was set in place on 7 July. The spillway traps were checked daily; the frequency of checks depended on the degree of fish movement and the amount of debris in the traps. In 1983, the spillway trap was operated until 24 November, when icing conditions curtailed its further use. The two spillway traps employed in 1984 were set until 20 November when it became evident that fish movements out of the Saskeram Marshes had ceased.

The fish ladder in Bracken Dam was also utilized to monitor the emigration of fish from the Saskeram Marshes. The fish ladder was converted into a downstream trap by screening off the first compartment below the fish ladder exit. The fish ladder could be almost entirely dewatered by shutting off the flow into it. This allowed personnel to enter the fish ladder compartment to count and remove the trapped fish. On several occasions, both in 1983 and 1984, difficulties were experienced in holding the fish ladder screen intact. These difficulties resulted when large numbers of small pike or Brook Stickleback, *Culaea inconstans*, became impinged on the screen or caught in the small mesh, causing the screen to give way to the force of water flows. On these occasions, an unknown number of fish passed down through the fish ladder.

All downstream moving fish, except forage species, caught in the spillway and fish ladder traps were counted. In counting the pike, underyearling

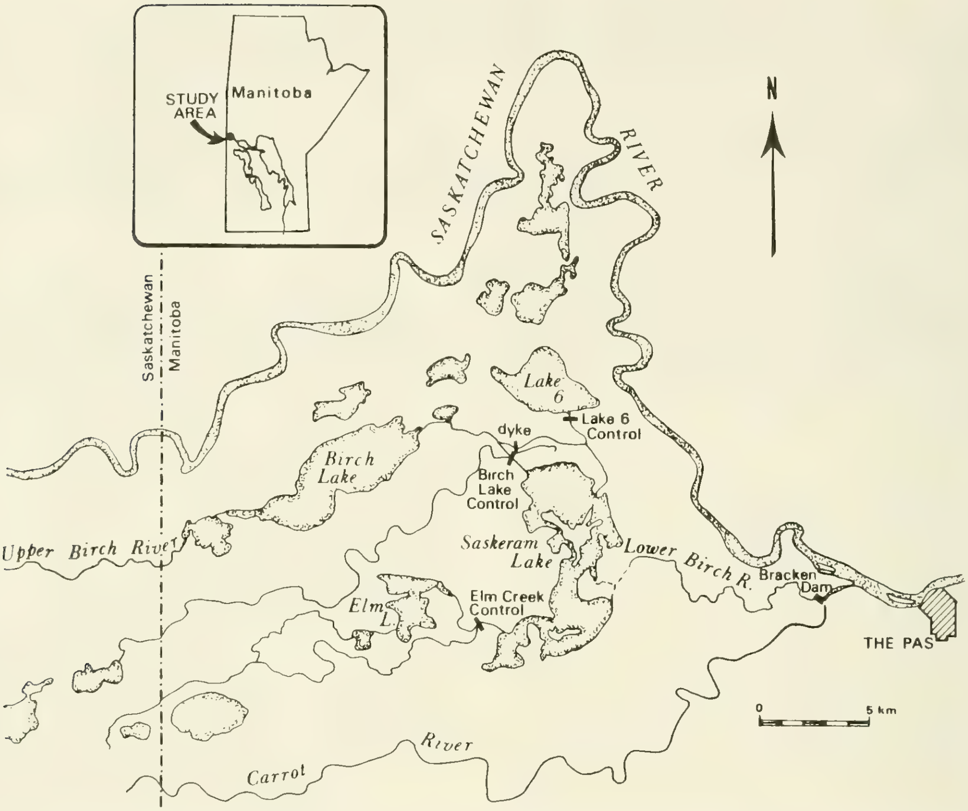

FIGURE 1. The Saskeram Marshes, bounded by the Saskatchewan and Carrot rivers, in west-central Manitoba.

pike could be readily distinguished from yearling and older pike on the basis of size alone. This was confirmed by observations on the seasonal growth of young-of-the-year pike. In the two years of study, young-of-the-year pike constituted 97% of the combined annual catches of pike. The daily catches of underyearling pike in each year were grouped into 5-day periods and expressed as means. These means were plotted on a logarithmic scale against time.

Results

Over 80 000 underyearling pike moved out of the Saskeram Marshes in the two years; 35 289 in 1983 and 45 215 in 1984. Considering the gear problems encountered in both years, the escapement of underyearlings may well have been in excess of 100 000. The estimated total biomass of the enumerated pike which left the marshes in both years was 13 400 kg.

Comparisons of catches made over time in the two years indicate that the exodus of underyearling pike from the Saskeram Marshes is consistent (Figure 2). Although some young pike moved out of the Saskeram Marshes during the summer, the bulk of the movements did not begin until autumn. The relatively small numbers of young pike which were captured in July and August in both years may have been fish which were spawned in or near the lower Birch River. It is not known whether the development of summerkill conditions in the marshes during 1983 (Derksen and Gillies 1985) was responsible for the greater number of summer migrants in that year. The major outmigration in each year began between the latter part of September and the first week of October. This movement may have been stimulated by a decline in water temperatures to below 10° C; in both years water temperatures dropped and remained below 10°C by the third week of September. Peak movements of underyearling pike occurred from approximately mid-October to mid-November.

Dissolved oxygen levels and the onset of anoxic conditions within the marshes evidently controlled the continued outward migration of young pike. In 1983, outmigration did not stop until mid-December (Figure 2). Dissolved oxygen levels within the lower Birch River at this time were still in the order of 1.0 mgL^{-1}. Oxygen levels recorded in the vicinity of Saskeram Lake on 13 December

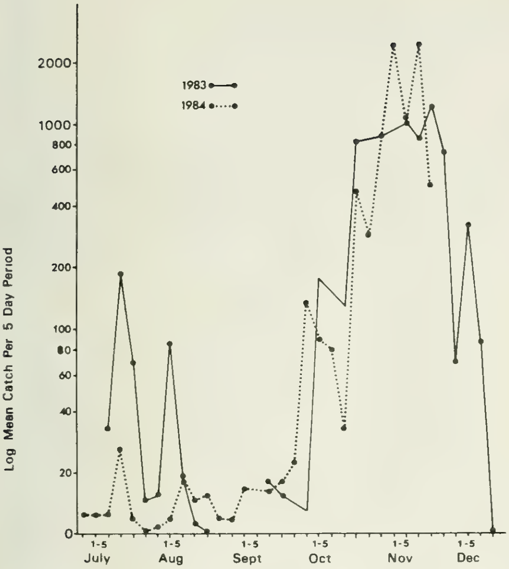

FIGURE 2. The outmigration of underyearling Northern Pike from the Saskeram Marshes in 1983 and 1984, as indindicated by mean catches at Bracken Dam per 5-day periods.

1983, were below 0.5 mgL-1 and there was a detectable sulphide odour in the water. In 1984, the outmigration ceased abruptly after mid-November. By 13 November, the Saskeram Marshes had frozen over and water leaving the marshes had a noticeable sulphide odour. Dissolved oxygen levels in surface water above Bracken Dam dropped to less than 1.0 mgL-1 by 17 November.

The above, along with other information, was considered in providing Ducks Unlimited with recommendations on water level management in the Saskeram Marshes (Derksen and Gillies 1985). These recommendations were aimed at enhancing pike production from the Saskeram Marshes and reducing the severity of winterkills.

Acknowledgments

I thank H. Schell who drafted the figures in this report.

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News and Comment

World Wildlife Fund's Wildlife Toxicology Fund

This research grant program is a co-operative initiative of Environment Canada and World Wildlife Fund. The Wildlife Toxicology Fund supports high-calibre research on the effects of toxic chemicals on wildlife.

Researchers are invited to submit applications which focus on:

- Assessment of the effects on wildlife and habitat of toxic substances enumerated on the Priority Substances list of the Canadian Environment Protection Act and corresponding Acts of participating Provincial Governments.
- Assessment of the impact on wildlife and habitat of pesticides, both chemical and microbial, listed on the Department of the Environment's priority list for review under the Pest Control Products Act or equivalent priorities identified by participating Provincial Governments.
- Topics of concern identified by the Canadian Wildlife Service component of the inter-departmental Long Range Transport of Airborne Pollutants Program.

This fund is particularly interested in receiving applications for research in the following areas:

- Effects of toxic chemicals on estuarine and marine environments; terrestrial species; and ecosystems, including the Arctic.
- Effects of pulp mill effluents and pesticides on wildlife and habitat.
- Comparative toxicology examining the effects of toxic chemicals on a wide range of organisms.
- Inter-university studies.

The Wildlife Toxicology Fund supports up to one-half the cost of approved research proposals, provided matching funds can be found from other sources. In addition to Environment Canada and WWF, support for the WTF have been received from the Ontario Ministry of the Environment, the Quebec Ministry of the Environment, Noranda Inc., Inco Ltd., Alcan Aluminum Ltd., the Department of Fisheries and Oceans, the Quebec Wildlife Foundation, Northern Reflections and Ontario Hydro.

For details contact your local university's research officer or: Executive Co-Ordinator, Wildlife Toxicology Fund, c/o World Wildlife Fund Canada, Suite 201, 60 St. Clair Avenue East, Toronto, Ontario M4T 1N5. Telephone (416) 923-8173.

MARGARET CHRUMKA
Projects Administrator, World Wildlife Fund Canada

Rare Lichens Project

A project to determine the conservation status of the lichens of North America north of Mexico, and Hawaii was recently begun by Mason E. Hale, Jr., and Sherry K. Pittam of the Department of Botany, Smithsonian Institution, in cooperation with The Nature Conservancy.

The project's goal is to generate a list of rare or endangered lichens with the necessary information to seek protection for species as appropriate, and to provide this information to the Conservancy and to other conservation organizations and land-management agencies. When possible, potential threats to individual species, as well as geographic distribution and abundance, will be noted. Taxonomy will follow Egan's checklist (as revised).

Those interested are invited to provide names of potentially rare or endangered species of lichens, with available supporting information.

SHERRY K. PITTAM
Rare Lichens Project,
Smithsonian, Botany/NHB 166, Washington, D.C. 20560 Telephone: (202) 357-2545

Food Web Collection Available in Machine-Readable Form

A collection of more than 200 food webs is available in machine-readable form (5-1/4 inch floppy disks for IBM-compatible personal computers using DOS file structure). Version 1 of this co-operative collection contains portions of the compilations of J. E. Cohen, F. Briand, A. King and S. L. Pimm, and K. G. Schoenly and R. A. Beaver. Other webs will be added. The disks give, for each web, a citation of the original source, the name of the contributor, an edited predation matrix, and a list of organisms. The data base is available to research ecologists for the cost of handling. It is available free to research ecologists who contribute, in appropriate format, one or more published webs that are accepted for addition to the data base. For details of format and conditions of use, contact:

JOEL E. COHEN
Ecologists' Co-Operative Web Bank™ (ECOWeB™), Rockefeller University, Box 20, 120 York Avenue, New York, NY 10021-6399.

Minutes of the 110th Annual Business Meeting of The Ottawa Field-Naturalists' Club: 10 January 1989

Place and Time: Auditorium, Victoria Memorial Museum Building, Metcalfe and McLeod Streets, Ottawa, 20:07 hrs.

Chairman: Dr. W. K. Gummer, President

Attendance: Forty-two people attended the meeting.

1. Minutes of the Previous Meeting

Doreen Duchesne, Acting Recording Secretary, read the minutes of the 109th Annual Business Meeting. It was moved by Frank Pope (2nd Ellaine Dickson) that the minutes be approved.

(Motion Carried)

2. Business Arising from the Minutes

Bill Gummer made the following points:

a) Although not yet successful, some action has been taken by Jeff Harrison and Bill Gummer to find permanent office space for the Club.

b) Regarding the point made under Conservation Committee about no response having been received from two Ministries of the Ontario government concerning Stony Swamp: after last year's Annual Business Meeting, the Ministry of Natural Resources wrote that municipalities around Stony Swamp weren't following Ontario government wetlands policy.

c) The publications policy was revised to reflect the loss of *The Shrike* and changes made to *Trail & Landscape*.

d) The new Club brochure, which will be available shortly, was jointly produced by Conservation Committee, Education and Publicity Committee and Membership Committee.

Roger Taylor mentioned that the Bird Watchers Badge Programme, set up by the Canadian Nature Federation and the Canadian Wildlife Service, was successful.

3. Financial Report

[The Financial Statements are appended at the end of the Minutes.]

a) Frank Pope (Chairman of the Finance Committee) presented the financial statements. He reported that Janet Gehr is the new Treasurer, replacing Frank Valentine.

b) The Chairman thanked Lois Cody for handling the mail, posting ledgers and issuing receipts, and Bill Cody for managing the funds.

c) This year there is no statement from the auditor. This will be explained in more detail later on.

d) Regarding the financial statements, Frank Pope pointed out that members' equity rose from $76 718 in 1987 to $90 870 in 1988 thanks to sound management. He noted that certain items such as "fixed assets" and "funds" were explained in the footnotes. One member of the audience wanted to know what "fixed assets" consisted of. He was told it was mainly the Club's computer which is being depreciated on a straight line basis.

Particular items noted by Pope to explain the rise in members' equity included the OFNC's net income of $4046 in 1988 compared with a loss of $360 in 1987, and an increase in the **CFN**'s net income to $12 212 in 1988 from 3 662 the year before. The Statement of Operations for the OFNC reveals increased income from membership fees. (There was a fee increase last year and a reduction in expenses.) The **CFN**'s Statement of Operations shows an income of $25 023 derived from the sale of reprints in 1988 compared with $7 992 in 1987. (Footnote 5 explains the large increase in revenue — mostly due to COSEWIC Reports). One member asked if the COSEWIC reports were a continuing item. The response was that they would be in the coming year, although to a lesser extent; it wasn't clear what would happen after that.

It was moved by Frank Pope to accept the Financial Report (2nd Don Davidson).

(Motion Carried)

4. Nomination of Auditor

a) This year the books were not audited. The auditor was out of town when contacted and his firm does not operate in January. An audit assures the membership that the finances are being well managed. There is no legal requirement to have the books audited and the Club has a good record of financial management (which is monitored by Finance Committee). However, the Club's Constitution has an article calling for the nomination of an auditor at the Annual Business Meeting, who is expected to be a qualified professional. Pope screened a list of present and past Finance Committee members to find a qualified auditor who would audit the Club's books free of charge. He was unsuccessful in finding a suitable person. He felt the matter of appointing a new auditor and dealing with the current problem of unaudited books should be dealt with by Finance Committee.

One member suggested that a note be published in **CFN** to explain the situation and that Monty

Brigham (the Club's current auditor) would probably audit the books on his return. Another member questioned the need for the auditor to be a professional. This person was told that the new Treasurer wanted to do things properly, according to the Constitution.

It was moved by John Sankey (2nd Ellaine Dickson) to nominate Monty Brigham as auditor for the coming year — subject to his approval. *(Motion Carried)*

b) Various other comments from the audience included a repetition of the opinion that it should not be necessary for the audit to be performed by a professional; the Club should follow the by-law, otherwise the by-law should be changed; and there should be enough time between the end of September and the Annual Business Meeting to do an audit. To this latest comment, Pope responded that the books are not available until the beginning of December which allows the auditor one month to do the audit.

5. Report of Nomination Committee

a) Barbara Campbell (Chairman) thanked Ellaine Dickson and Ken Strang for joining her on the Committee.

b) She reported the following members nominated for the 1989 Council:

President:	Jeff Harrison
Vice-Presidents:	Roy John
	Ken Strang
Treasurer:	Janet Gehr
Recording Secretary	Doreen Duchesne
Corresponding Secretary:	Martha Aksim*

Other Council members:

Ronald Bedford
Barry Bendell
Bill Cody
Robin Collins*
Francis Cook
Don Davidson*
Ellaine Dickson
Eileen Evans
Elizabeth Fox*
Deirdre Furlong*
Bill Gummer
Elizabeth Morton*
Catherine O'Keefe
Frank Pope
Karen Richter*
John Sankey*
Austin Taverner*

*New member of Council

The following Council members resigned during the year (*) or are retiring now:

Dan Brunton*
Barbara Campbell
Kathleen Conlan*
Peter Croal
Barbara Desrochers
Peter Hall
Shane Jordan
Wright Smith
Frank Valentine*
Paul Ward*

It was moved by Barbara Campbell (2nd Colin Gaskell) that the slate of nominations be approved. *(Motion Carried)*

6. New Business

a) As outgoing Club President, Bill Gummer said he had been honoured and flattered to have occupied this position. He greatly enjoyed it and thanked Council and other members who have helped him over the years. He said many members shoulder a heavy load; these people keep the Club active and strong. He mentioned several issues the Club may be concerned with in the future and welcomed Jeff Harrison as the new Club President.

b) Jeff Harrison thanked the Council for its work in 1988 and thanked Bill Gummer for three years of dedicated service as President. He said that Bill did a good job of maintaining stability and direction during this period. Jeff has been a member of the OFNC for about 15 years. He stressed that the Club could not function without people like Bill Cody, Ellaine Dickson, Joyce Reddoch, Peter Hall, the *T & L* team, Frank Pope (who did much towards the acquisition of Alfred Bog), Eileen Evans, Barbara Campbell, and many others.

7. Report of Council

All reports this year were approved by Council or Executive Committee, on time for the Annual Business Meeting. The reports were read and discussed as follows. [Full reports are appended at end of Minutes following Financial Statement].

a) *Awards Committee*

The report was read by Bill Gummer. There were no questions or comments.

b) *Birds Committee*

The report was read by Jeff Harrison. There were no questions or comments.

c) *Computer Management Committee*

The report was read by Ken Strang. A member wanted a clarification over the acquisition of software. He was told that the Club had purchased dBASE III and that Ashton-Tate had donated dBASE III Plus.

d) *Conservation Committee*

The report was read by Bill Gummer. One member wanted to know what he could do to help save the coral reefs. He was told to contact Dr. Don E. McAllister at the Museum of Natural Sciences.

Frank Pope mentioned that approximately $14 000 in donations had been received from Club members to date towards the purchase of Alfred Bog.

e) *Education and Publicity Committee*

The report was read by Jeff Harrison. There were no questions or comments.

f) *Excursions and Lectures Committee*

The report was read by Ken Strang. There were no questions or comments.

g) *Finance Committee*

The report was read by Bill Gummer. One member wanted more information on the financial implications of the sale of *Lichens of the Ottawa Region*. He was told that the Club had published about 1180 copies and that the break even point was approximately 500–600 copies. Jeff Harrison has developed a marketing strategy. The proceeds are to be used to help purchase Alfred Bog.

h) *Macoun Club Committee*

The report was read by Jeff Harrison. Fenja Brodo said she was surprised to see her name on the membership list since she had not been asked to attend a meeting for a long time.

i) *Membership Committee*

The report was read by Ken Strang. There were no questions or comments.

j) *Publications Committee*

The report was read by Bill Gummer. It was mentioned that Joyce Reddoch will have been editor of *T & L* for 10 years with the completion of Volume 22, and that profits from the sale of *Nature and Natural Areas in Canada's Capital* were to go to Alfred Bog. Jeff Harrison was thanked by Fenja Brodo for his efforts in marketing *Lichens of the Ottawa Region*.

At this point one member wanted to know why a $350 donation from Excursions and Lectures Committee to the Macoun Club for a trip in 1988 was not mentioned in the budget. The response was that this item was included in extra funding allocated for the Macoun Club in 1989.

It was moved by Barbara Campbell (2nd Roger Taylor) to accept the Report of Council, with amendments as suggested at the meeting. *(Motion Carried)*

8. Adjournment

John Sankey (2nd Barbara Campbell) moved that the meeting be adjourned. (Time 21:54 hrs.) Members were invited to the Salon for refreshments following the meeting.

Auditor's Report

I have examined the balance sheet of The Ottawa Field-Naturalists' Club as at September 30, 1988 and the statements of operations for the year ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Corporation as at September 30, 1988 and the results of its operations for the year ended, in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

F. MONTGOMERY BRIGHAM

Ottawa, Canada
March 1989

Note by the Finance Committee

The audit of the financial statements could not be completed before the 110th Annual Business Meeting. At that meeting, the financial statements were accepted, pending their acceptance by the auditor. As indicated above, the audit has been completed and the auditor has found that the financial statements present fairly the financial position of the Club at September 30, 1988.

FRANK POPE
Chair, Finance Committee

The Ottawa Field-Naturalists' Club
Financial Statements For The Year Ended September 30, 1988

The Ottawa Field-Naturalists' Club
BALANCE SHEET

As At September 30, 1988

	1988	1987
Assets		
CURRENT		
Cash	$133 732	$115 139
Accounts Receivable	21 245	12 139
Interest Receivable	464	133
Prepaid Expenses	—	1 095
	155 441	128 506
FIXED (Note 3)	1 030	2 461
LAND — Alfred Bog	3 348	3 348
	$159 819	$134 315

Liabilities, Funds, and Members' Equity

	1988	1987
CURRENT		
Accounts Payable	$ 46 662	$ 31 819
Deferred Income	12 000	10 552
	58 662	42 371
FUNDS (Note 4)	4 287	9 626
LIFE MEMBERSHIPS	6 000	5 600
MEMBERS' EQUITY	90 870	76 718
	$159 819	$134 315

The Ottawa Field-Naturalists' Club
Statement of Members' Equity

For The Year Ended September 30, 1988

	1988	1987
EXCESS INCOME (EXPENDITURES)		
The Ottawa Field-Naturalists' Club	$ 4 046	$ (360)
Canadian Field-Naturalist	12 212	3 662
	16 258	3 302
OTHER INCOME (CHARGES)		
Donations and Grants	1 993	2 000
Trail & Landscape Index	(1 659)	206
Records and tapes	(2 440)	201
	14 152	5 709
MEMBERS' EQUITY, BEGINNING OF YEAR	76 718	71 009
MEMBERS' EQUITY, END OF YEAR	$90 870	$76 718

The Ottawa Field-Naturalists' Club
STATEMENT OF OPERATIONS — OFNC

For The Year Ended September 30, 1988

		1988	1987
INCOME			
Membership Fees		$13 131	$12 000
Trail & Landscape			
Subscriptions	416		391
Back Numbers	222		119
		638	510
Interest		1 514	917
Other Sales		203	—
		15 486	13 427
EXPENSES			
Trail & Landscape			
Printing	4 031		5 764
Circulation	371		352
Production	758		670
Honorarium	605		605
		5 765	7 391
Committees (Net)			
Excursions and lectures	(1 839)		(945)
Membership	1 259		1 389
Macoun Field Club	702		641
Conservation	120		53
Birds	121		69
Education and Publicity	421		—
Computer	490		
		1 274	
Affiliation Fees		230	280
Office Assistant		520	495
Office Supplies and Expense		2 220	2 479
Special Publications		—	285
Depreciation		1 431	1 431
		11 440	13 787
EXCESS OF INCOME OVER EXPENSES		$ 4 046	$ (360)

The Ottawa Field-Naturalists' Club
Statement of Operations — CFN

For The Year Ended September 30, 1988

		1988	1987
INCOME			
Membership Fees		$ 9 500	$ 8 000
Subscriptions		23 582	22 195
		33 082	30 195
Publication			
Reprints	$25 023		7 992
Plates and Tab Settings	3 513		2 733
Extra Pages	26 700		27 593
Back Numbers	417		1 388
		55 653	39 706
Interest		6 123	3 872
Exchange		1 520	2 779
		96 378	76 552
EXPENSES			
Publishing	57 975		55 555
Reprints	11 436		4 034
Circulation	5 976		4 983
Editing	2 849		2 500
Office Assistant	3 360		3 204
Office Supplies	596		640
Honorarium	1 974		1 974
		84 166	72 890
EXCESS INCOME OVER EXPENSES		$12 212	$ 3 662

The Ottawa Field-Naturalists' Club
Notes to the Financial Statements
September 30, 1988

1. *Authority and Activities*

The Ottawa Field-Naturalists' Club is a non-profit organization incorporated under the laws of the Province of Ontario (1884). *The Ottawa Field Naturalists' Club* promotes the appreciation, preservation and conservation of Canada's natural heritage; encourages investigation and publishes the results of research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with organizations engaged in preserving, maintaining or restoring environments of high quality for living things. Membership is open to any person or family, upon application and payment of dues. Payment of the Annual

Dues as set out in the By-laws will be a necessary condition for the continuance of Membership.

2. *Significant Accounting Policies*

Memberships, subscriptions and donations are recorded as received. All other revenues and expenditures except for inventory are accounted for on the accrual basis. Memberships are allocated to *The Canadian Field-Naturalist* publication on a predetermined percentage.

Supplies, records, tapes and other items held for resale are expensed when purchased.

Fixed assets are recorded at cost and are depreciated on a straight-line basis.

Life memberships paid since 1977 are recorded at the fee in effect at that time. There are 38 life members.

3. *Fixed Assets*

Cost	$7156
Accumulated Depreciation	6126
Net book value	$1030

4. *Funds*	1988	1987
Baldwin Memorial Fund...	$ 358	$ 258
Seedathon	1104	1064
Anne Hanes Memorial Fund	865	841
Alfred Bog	1960	7463
	$4287	$9626

5. *Significant Events*

During the year, the Club received over $13 000 in revenue for reprints for *The Canadian Field-Naturalist* from the Department of Oceans and Fisheries, COSEWIC, which resulted in a large increase in CFN revenue. This is expected to occur again in 1989 to a lesser extent.

Committee Reports for 1988

Awards Committee

The Committee considered 29 nominations for Club and other awards, and Council accepted the Committee's recommendations at the meeting held 8 February 1988.

Club awards for 1987 were as follows:

Honorary Member: Ibra Conners, a long-time OFNC member

Member of the Year: Colin Gaskell, for his efforts with Excursions and Lectures Committee

Service: Gordon Pringle, for his successful and dependable efforts to advance Club birding activities

Conservation: C. Graham MacNay, for perserverance in developing a successful and effective bluebird trail

Anne Hanes Natural History Award: Jack Holliday, for his observations and writings on a variety of natural phenomena

President's Prize: Dianna Thompson, for her very successful efforts on behalf of the Club in preparing and operating an exhibit for the NCC's Fall Rhapsody

Citations were read and presentations were made at the Soirée on April 29, with all recipients present except Ibra Conners. Citations appeared in *Trail & Landscape* 22(3) and will also appear in *The Canadian Field-Naturalist* 103(4).

No outside awards were recommended, but a nomination was submitted for the FON Adult Summer Camp Scholarship.

Committee Members: D. F. Brunton (*Chairman*), E. Frankton, W. K. Gummer (*President*), P. W. Hall, D. Laubitz, M. Stuart.

(W. K. GUMMER)

Birds Committee

Our major highlight this year was the Peregrine Release Program. The volunteers were once again coordinated by Marg Benson. Perhaps the most pleasing aspect of this program is that it involved many people from the general Club membership as well as the core group of more active birders. We understand that this is probably the last release of Peregrines in Ottawa for some time as the mass release approach moves to other locations. We now need to watch for Peregrine returns and signs of breeding activity.

Bruce Di Labio, who has been the mainstay of our Seedathon effort was not able to go out this year; consequently the fund is low. We were able, however, to raise $400 from 60 contributors and will be able to carry on unless there is a big finch year. One hundred dollars has been reserved to assist the Hull club with improvements in the parking situation which is unsafe at the Pink Road feeder.

Some of our members again helped staff the Fall Rhapsody program.

Tony Beck has made a good start on organizing the photo-duplicate collection. We have a written catalogue of the photographs present and we are actively soliciting new additions. Tony made a presentation of this material at the December monthly meeting.

Our annual counts at Christmas and in the spring and fall were completed as scheduled. Tony Beck and Daniel Perrier have taken over as principal co-ordinators in the spring and fall.

The bird-status line had a successful year of operation thanks to Larry Neily's able efforts. It was necessary to purchase a new phone recorder part way through the year.

The Records Subcommittee met twice and processed reports of significant sightings. The Subcommittee will miss the contributions of R. Ross Anderson who passed away in August. Ross was one of our newer members and we had hoped to benefit from his extensive banding experience.

Stephen Gawn has taken up the final preparation of an article on "Birding Ethics" to add to the new members' package.

We had planned on updating the Committee's materials in the Public Archives but did not have time to do so.

The Shrike data base has been archived on IBM-PC data diskettes for safekeeping.

Committee Members: *Chairman:* Gordon Pringle; *Vice-Chairman:* Mike Runtz; *Secretary:* C. Wright Smith; *Financial Officer:* Michelle Elder; *Council Liaison:* C. Wright Smith; Tony Beck; Marg Benson;

Allan Cameron; V. Bernie Ladouceur; Larry Neily; Daniel Perrier; Joyce Reddoch; John Sankey; Ken Strang (*Vice-President*); Art Thompson; Daniel Toussaint.

Bird Records Subcommittee Members: *Chairman:* Mike Runtz; *Secretary:* Gordon Pringle (non-voting); *Council Liaison:* Bill Gummer (President); Ross Anderson (dec.); Robert A. Bracken; Bruce Di Labio; Mark Gawn; Robert Gorman; V. Bernie Ladouceur; *Current alternates:* Monty Brigham; Simon Gawn; Stephen Gawn; Jim Harris; Roy John.

Inventory: (1) Photo-duplicate collection/Tony Beck; (2) Answering machine/Larry Neily; (3) Feeders at: (a) Jack Pine Trail/Roy Millen; (b) Davidson Road/George McGee, Bill Moore; (c) NRC/Daniel Perrier.

(G. PRINGLE)

Computer Management Committee

The Computer Management Committee helps to ensure the efficient and controlled use of the computer assets of the Club. This year, we sought to increase the other Committees' awareness of how the computer can help them with their various needs while maintaining and improving existing systems. The following is a brief account of some of this year's achievements.

We upgraded the output of mailing labels using label "print files" and two-up (across) labels rather than one-ups, resulting in increased speed and efficiency while reducing wear and tear on the equipment.

To encourage use of the Club computer assets we developed guidelines for data submissions and distribution. We prepared guidelines for user and system manuals to provide a pleasant learning environment and thorough systems documentation. When necessary, we provided software and hardware support.

Council approved the purchase of FASTBACK as the OFNC data systems backup software package, which will protect against data loss or corruption and facilitate backup procedures.

Our first new application was to simplify the Club's forecasting and scheduling processes. After assessing individual Committees' scheduling needs, we recommended the purchase and installation of Calendar Creator Plus. We received approval by Council and are now implementing the application.

A hard disk failure last December prompted several concerns about the future of the Club's software and hardware. The event led to the acquisition of dBASE III Plus, COMPLIMENTS of Ashton-Tate. Now the prospects for new developments are much greater!

We want to extend a special thanks to Patricia Narraway, the OFNC computer operator, Dr. Coad and staff at the Museum of National Sciences for their continuing support and for helping to keep the OFNC's computer operations running smoothly. Also, we thank Ashton-Tate for his donation of a copy of dBASE III Plus. Finally, I thank our dedicated members who have volunteered their time and expertise to help us all meet Club objectives.

Committee Members: *Chairperson:* Suzanne Blain; *Council Liaison:* Ken Strang (*Vice-President*); *Assistant:* George Buchanan.

(SUZANNE M. BLAIN)

Conservation Committee

Awareness of the environment and the many issues involved in its conservation continued to grow with Canadians in 1988. This required the Committee to increase its vigilance and activities to respond to many new concerns, particularly on a local level. Several new initiatives were also undertaken to assist the Club in keeping a higher conservation profile in the region. The following is a list of the major issues involving the Committee in 1988.

National and Provincial

Consultation with the Ontario Ministry of Natural Resources included:

Amendments to the Ontario Game and Fish Act: Met with a representative of the OMNR to discuss proposed changes to the Act. A response from the Club was prepared outlining OFNC concerns.

Westmeath Provincial Park: Drafted a response to the park's Management Plan in which the Club supported a nature reserve designation.

Lanark Crown Land Management Plan: Concerns with the plan, particularly the lack of life sciences inventories, were forwarded to the OMNR. The situation was monitored throughout 1988.

(On the above and other management issues, the Committee met with OMNR officials in December to ensure that OFNC input into provincial environmental concerns was heard, and to hear first-hand OMNR's plans for natural resource management.)

Toronto Wetlands Conference: Committee members attended the conference in October and subsequently drafted a response to the new provincial wetlands policy.

Zoo Check: Offered support and drafted a response to a proposal that roadside zoos should be regulated.

Alfred Bog: Committee members participated in public relations and fundraising activities to help preserve the bog. Activities concentrated on the announcement of the major purchase of a part of the bog by the Nature Conservancy of Canada.

Local

Regional Municipality of Ottawa-Carleton (RMOC) Plan Review: Reviewed proposed changes and discussed their possible impact with RMOC staff.

Marlborough Forest Committee: The committee, made up of representatives of a variety of interested groups including the OFNC, met several times during the year to oversee the long-term use made of the forest.

Regional Development Issues: Committee members spent a great deal of time working with different political levels in the region to voice Club concerns over a variety of development issues, including housing proposals near Pinks Lake in the Gatineau Park and on the border of Stoney Swamp, as well as the leasing of National Capital Commission lands for development by Bell Northern in Kanata. In addition, the Committee monitored situations concerning environmentally sensitive lands along the Cumberland riverfront in South Gloucester and on Canadian Mortgage and Housing Corporation lands in Gloucester.

Municipal Election Questionnaire: Worked on a prototype questionnaire to canvass municipal politicians' responses to major environmental concerns.

Gatineau Park Master Plan: Ensured representation of the Club during a series of National Capital Commission consultations in preparation for developing a new Master Plan.

Wildlife Garden: Options for the development of a wildlife garden to act as a model for Ottawa residents were explored with several public landowners. Plans for the garden are now being developed in the hope work can proceed in 1989.

Many thanks to the Committee members who have worked so steadily during the past year to effectively represent the Club on many and varied environmental issues.

Committee Members: Peter Hall (*Chairman*); Suzanne Blain; Eleanor Bottomley; Peter Croal; Don Cuddy; Barbara Desrochers; Shane Jordan; Geoffrey Katz; Heidi Klein; Fern Levine; Lynda Maltby; Barb Martin; Michael Murphy; Joyce Reddoch; Richard Scott; Ken Strang (*Vice-President*); Roger Taylor; Ewen Todd; Jane Topping; Deb Walsh; Mike Walsh.

(P. W. HALL)

Education and Publicity Committee

The Committee's major achievement in 1988 was the purchase and completion of a new, more polished Club display. The driving force behind this accomplishment was Barbara Desrochers.

This year's Committee membership consisted of four new members out of seven, and was without a Chairperson until September. Consequently, several critical areas were neglected. For example, there was virtually no advertising done through the local media.

We received a scant three requests for speakers this year, only one of which was filled. (Bill Royds spoke on wildflowers at the Billings Estate on "Garden Day", July 3.)

The Club was a first-time participant in National Wildlife Week, April 8-10. The new display was set up and manned by 18 volunteers.

Ken Taylor once again coordinated the Club's involvement in the Ottawa Regional Science Fair, April 15-17. There were very few natural science projects. As a result, a single award was given to Derrick Moores, an intermediate student, for "Fish and Salinity".

The Committee helped develop a new Club brochure/membership application form in conjunction with Membership Committee.

The Club was involved in Fall Rhapsody and will receive $300 from the NCC for its participation. The bird feeder display required by far the most manpower and organization of all events the Committee was involved in this year. More than 23 volunteers were enlisted over a period of five days during the September 18 to October 10 period. The daily set-up and removal of the display resulted in problems with the storage of materials and the temporary loss of display parts. Contact with the NCC had to be maintained on a regular basis to ensure that all necessary details were attended to. During the event, the NCC contact indicated that she felt a bilingual display was "essential" and that the NCC might be unable to supply French volunteers for next year's display. The NCC is presently undergoing a reorganization. Its expectations of the OFNC for next year's Fall Rhapsody will not be confirmed until July 1989.

Eighteen volunteers helped out this year at the Duck Club Nature Art Show, October 21-23. Club sales from the event approximated $500 (including the sale of 43 copies of Dan Brunton's book *Nature*).

The National Museum of Natural Sciences Clubs' Day did not take place this year due to reorganization problems.

At the November 8 OFNC monthly meeting, the practice of selling Club articles resumed. Over $50 was raised. On New Members' Night the display was set up at the Museum. A number of items were sold.

Committee materials and notes are being organized to ensure continuity for future chairpersons and members. A list of annual meetings and the Committee's annual agenda of events were prepared to aid members in planning for the coming year.

The Committee met for the last time in 1988 on November 9. Martha Aksim agreed to co-chair with Deirdre Furlong in the coming year. Two potential members who were invited to the meeting showed considerable enthusiasm in staying with the Committee. The group offered many constructive ideas for the new year.

All told, prospects for 1989 are looking much brighter. Martha and Deirdre look forward to a more productive year with the Education and Publicity Committee.

Committee Members: *Co-Chairpersons:* Jeff Harrison (*Vice-President*) and Deirdre Furlong; Martha Aksim; Barbara Desrochers; Doreen Duchesne; Bill Royds; Ken Taylor.

(DEIRDRE FURLONG)

Excursions and Lectures Committee

The Committee has been busy with the planning of over 65 events this past year. Activities planned and carried out were as follows: 26 half-day trips; 9 all-day trips; 5 bus trips; 2 overnight trips; 15 lectures and special events.

"Lectures and special events" included monthly meetings, the Annual Soirée, tours of Carleton University's greenhouses and the National Museum's ornithology collection, and the very popular botany identification evening with Dr. Erich Haber. In addition, we ran our annual amphibian, butterfly and mushroom outings, which are also always popular. The trip to Derby Hill, N.Y. for the hawk migration was rained out, as was our family outing.

The highlight of the year was a nine-day trip to Grand Manan Island and area. Forty members, including our able leaders Roy John and Colin Gaskell, were treated to sights of whales, dolphins, tidal life, plants, beautiful scenery, fog and *BIRDS*. Imagine seeing over 50 000 shorebirds on one small beach, lifting and wheeling, to land again closer to you.

This Committee worked without a chairman. Special thanks must be given to Eileen Evans for her effort in making our social evenings successful, and to Colin Gaskell who put everything together and also planned, managed and led the Grand Manan trip.

The success of the 1988 agenda is a direct result of the efforts of our leaders, speakers and Committee members. Thanks to all.

Committee Members: Ross Anderson; Robina Bennett; Marg Benson; Ellaine Dickson; Eileen Evans; Jeff Harrison (*Vice-President*); Colin Gaskell; Christine Henri; Edith Ikeda; Rick Leavens; Philip Martin; Catherine O'Keefe.

(Ellaine Dickson)

Finance Committee

The Committee met four times during the year. Major activities included a review of the financial statements and accompanying notes, the compilation of a list of Club policies and Council motions regarding financial matters, a general review of the Constitution, Bylaws and terms of reference for positions related to finance, and a review of investment practices. In addition, the Council was advised on the financial implications of publishing *Lichens of the Ottawa Region.*

Significant events during the financial year included a minor reduction in the page dimensions of the *Canadian Field-Naturalist*, which resulted in reduced paper requirements and lower printing costs. During the year, Frank Valentine resigned as treasurer and was replaced by Janet Gehr.

Committee Members: Frank Pope (*Chairman*); Ronald Bedford; Bill Cody; Don Davidson; Sheelah Demetre; Janet Gehr; Ken Strang (*Vice-President*); Frank Valentine; Paul Ward; Ken Young.

(Frank Pope)

Macoun Field Club Committee

In 1988, the Macoun Field Club (MFC) celebrated its 40th anniversary. Committee members, led by Maria Darragh, carried out a number of projects representing the MFC's history and development: a historical scrapbook and slide collection; an anthology of *The Little Bear*; and a reunion of past members and leaders.

A series of meetings was devoted to field-trip issues, with opinions being sought from a number of former MFC leaders. Several documents relating to current practices were drafted. The most frequently used ones are guidelines for new field-trip leaders and children, and an outline of parental responsibilities.

At the end of the school year (which governs the MFC cycle), Paul Hamilton stepped down as leader after two full years of running the Club. Working with both the Committee and children, he accomplished a great deal by way of furthering the field-oriented character of the Club.

In departing, Paul advanced Heidi Klein's solution to the perennial problem of finding a new leader. As the chief factor wearing people out is the unrelenting, year after year commitment to run three meetings a week, he suggested that Committee members take month-long turns organizing the Club program. Under this arrangement, the Macoun Field Club leader would mainly serve to provide continuity to the children.

When co-leaders Rob Lee and Joe Shepstone took over from Paul in September, this system was put into practice. They soon found their work load much reduced. In October, Heidi developed a program of speakers and field trips that explored the effects of urban development on natural areas. Robin Collins and Joe followed with themes on astronomy and geology.

At the close of 1988, the numbers of children and young people in the MFC have reached satisfactory levels in only one of the three groups. There are 26 Juniors, but only 7 Intermediates and 14 Seniors. One-third to one-half of the members attend the field trips, which are held every second Saturday.

Because of the heavy field-trip load and the rotation of program scheduling duties, the Committee is constantly obliged to find new volunteers. People who wish to help out should expect to get involved with the children, but may be assured that, within the current framework, their commitment only need be occasional or short-term.

The Committee acknowledges with thanks the many people whose names do not appear on its roster — especially speakers and field-trip leaders — for having helped make each particular MFC meeting or outing a success.

Committee Members: Barry Bendell (*Chairman*); Robin Collins (*Interim Chairman*); Martha Camfield; Stephen Darbyshire; Maria Darragh; Ian Davidson; Ellaine Dickson; Lisa Fooks; Barbara Gaertner; Paul Hamilton; Heidi Klein; Robert Lee; Joe Shepstone; Ken Strang (*Vice-President*).

(Rob Lee)

Membership Committee

The total paid-up membership as of December 6, 1988 was 1165, a slight decrease of 12 from the 1987 total of 1177. Local membership increased by 26 members and non-local membership decreased by 38. The number of new members joining the Club was 146, an increase of 13 from the 133 who joined in 1987. Sustaining members totalled 35, a decrease of 7 from last year. There were no new life members this year. Family memberships totalled 340, an increase of 13. Based on an average of two members per family, we estimate the total membership served by the Club to be 1505.

The following chart summarizes the membership distribution. The figures in brackets are the 1987 totals.

1988 Paid-up Membership in the OFNC

	Canada		Foreign		
Type	Local	Other	USA	Other	Total
Individual	471 (454)	202 (232)	47 (52)	6 (7)	726 (745)
Family	315 (302)	24 (24)	1 (1)	0 (0)	340 (327)
Sustaining	33 (37)	2 (5)	0 (0)	0 (0)	35 (42)
Life	16 (16)	18 (18)	3 (3)	2 (2)	39 (39)
Honorary	16 (16)	7 (7)	2 (1)	0 (0)	25 (24)
Total	**851 (825)**	**253 (286)**	**53 (57)**	**8 (9)**	**1165 (1177)**

Fifty new names have been added to the volunteer list since last December and the various Committees have called on many of these volunteers for their assistance. The Committee would like to thank all those who have offered their services.

The Membership Committee and the Excursions and Lectures Committee once again co-hosted a very successful New Members' Night on November 18. Approximately 90 people, including several honorary members and members of Council, enjoyed wine, cheese and other refreshments in the Salon of the National Museum of Natural Sciences. A highlight of the evening was a brief history of the Club and its predecessors, illustrated by some fascinating old photographs. Many thanks are due to Dan Brunton for his excellent presentation.

The Chairman would like to thank the members of the Committee for their help in 1988, with special thanks to Ellaine Dickson who, though no longer an official member of the Committee, is always ready to assist. We would also like to thank Suzanne Blain and Patricia Narraway for their efficient operation of the computer and the staff of the National Museum of Natural Sciences (Beamish Building) for their generous assistance.

Committee Members: Eileen Evans (*Chairman*); Eleanor Bottomley; Barbara Campbell; Fran Goodspeed; Barbara Hurt; Edith Ikeda; Aileen Mason; Karen Richter; Bette Stern; Ken Strang (*Vice-President*); Doreen Watler.

(E. EVANS)

Publications Committee

The Committee met three times in 1988 in its function of overseeing and advising Council on the Club's publications.

Five issues of *The Canadian-Field Naturalist* were published in 1988: Volume 101, issues 3 and 4, and Volume 102, issues 1, 2 and 3. The five issues contained 964 pages consisting of 58 articles, 65 notes, 98 book reviews, 25 COSEWIC reports on endangered species, 679 new titles, 3 commemorative tributes, and 41 pages of news and comments. With the completion of Volume 101, Dr. Francis Cook became the most prolific editor in CFN history, including the volumes edited during his first term as editor from 1962 to 1966. For this we congratulate him. Volume 102 saw the introduction of a new format — slightly smaller, with little or no sacrifice in appearance and readability, but with a substantial decrease in production costs. The panel of Associate Editors remained unchanged, although Dr. A. Erskine has indicated his intention to step down soon. Mr. Harvey Beck has continued to do the indexing.

Volume 22 of *Trail & Landscape* was reduced to four issues annually. The cover illustration was changed one year ago. Four new covers depicting natural scenes throughout the seasons are the work of Marc Guertin. The Club is indebted to him for his work. The four issues of Volume 22 contained 192 pages, about 35% of which were related to birds. Dr. Joyce Reddoch has indicated her intention to step down as editor of *T & L* with the completion of Volume 23. The search for a successor is well in hand.

This year saw the publication of *Nature and Natural Areas in Canada's Capital* by D. F. Brunton. The production of this book was a cooperative effort between the Ottawa Citizen and the OFNC, with the former providing the financing and publishing.

Special Publication No. 3, *Lichens of the Ottawa Region*, by Dr. I. Brodo was also published this year. This is a second, revised and augmented edition of an out-of-print publication of the National Museum of Natural Sciences. E. Morton provided editorial services.

The Committee thanks the editorial and production staffs of the *CFN*, *T & L* and *Lichens of the Ottawa Region* for their service to the Club. The Committee also thanks the Ottawa Citizen for its cooperation, and all those persons who have contributed to the support of these publications.

Committee Members: R. Bedford (*Chairman*); P. Catling; W. Cody; F. Cook; W. Gummer (*President*); J. Harrison (*Vice-President*); J. Montgomery; E. Morton; J. Reddoch.

(RONALD E. BEDFORD)

Book Reviews

ZOOLOGY

The Birds of Africa: Volume III

Edited by C. Hilary Fry, Stuart Keith, and Emil K. Urban. 1988. Academic Press, New York. xvi + 611 pp., illus.

Appearing only two years after the publication of the previous volume, this book is even more substantial and attractive than its predecessors.

In the Introduction the editors discuss style, layout, the use of English names, and systematic treatment, including "new ideas about relationships among the higher taxa of birds." They also point out a few "novel proposals" of direct concern to this volume (e.g. that "turacos are not cuckoos but are distantly related to owls and nightjars," and that "larks are related to finches, and that pipits and accentors belong with the weavers in Ploceidae"). The editors warn the reader, however, that the new findings, based on recent DNA-DNA hybridization, paleontology, and anatomy "will dictate a radically new and heterodox classification of birds." Evidently, consensus among systematists is far from complete, and while the book cannot include all the proposed changes in the higher taxa, it does introduce some taxonomic changes (e.g. the editors recognize several new superspecies, and "demote" others from super to independent species). The Introduction also mentions that although range maps for this volume were prepared and presented as in Volume II, three explanatory maps were included: 1) to indicate "shading, symbols and arrows used on maps," 2) to update the political map of Africa, originally published in Volume I, and 3) to illustrate the climatic zones of East Africa.

The main body of the text deals with the following nine orders of birds: Psittaciformes, Musophagiformes, Cuculiformes, Strigiformes, Caprimulgiformes, Apodiformes, Coliiformes, Caraciiformes, and Piciformes. Good size range maps complement the descriptions of superspecies and individual species. As before, there is a general introduction to each order, family, sub-family, and genus. This is followed by sections on Range and Status, Description (adult male, female, immature and, when possible, downy young), Field Character, Voice, General Habits, Food, and Breeding Habits. Ian Willis' charming black and white line-drawings accompany the text. These illustrations, labelled with capital letters, correspond to the appropriate descriptions in the text of characteristic poses, plumage differences, food items, and downy young.

Martin Woodcock's thirty-two colour plates were painted between 1981 and 1984. The birds, grouped "according to affinity, resemblance, and geographic distribution" are shown in different postures "to characterize the appearance in the field of each genus or family." Most of the plates show large, well spaced figures. But others, e.g. the honeyguides and woodpeckers, needed diagrammatical "field-guide design." All in all, the plates are successfully done, and the colours are truly magnificent. There are a few problems, however. The white parts of several birds blend into the white background, and because of the lack of contrast, are difficult to see. Notable examples are the white belly of the Chocolate-backed Kingfisher (plate 16), and the white-headed phase of the Forest Wood-Hoopoe (plate 21), actually described in the text as "tinged pale buff" on the crown! A random sampling disclosed other discrepancies between the text and the illustrations. One of the sub-species of the Carmine Bee-eater is described as having pale blue undertail-coverts, but on plate 19 these are painted the same medium greenish-blue as the throat patch — described in the text as "dark green-blue"! In the discussion of the Tawny Owl field characters one reads: "sympatric with Long-eared Owl *Aslo otus* which is more slender . . . has yellow eyes and is relatively unmarked." But the field characters of the Long-eared Owl describe the bird, correctly, as having "streaked grey and brown plumage" and "deep orange eyes." The painting on plate 7 shows the orange eyes, and the underparts, with their characteristic cross-hatch pattern, are far from "unmarked."

The book contains an extensive three-part bibliography: 1) general and regional references; 2) references to each family of birds; and 3) acoustic references. The indices include a scientific name index and one each of English and French names.

The editors, artists, and contributors are to be congratulated on this scholarly yet readable series of well-illustrated volumes. The above mentioned discrepancies should deter no one, and in fact, reading the *Birds of Africa* is addictive. I can hardly wait for the publication of Volume IV! Although the price is likely to remain high, I would still recommend the book, and indeed the whole series, to all libraries and serious naturalists.

MARIANNE GOSZTONYI AINLEY

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Proceedings of the Second International Conference on Copepoda

Edited by G. Schriever, H. K. Schminke, and C.-t. Shih. 1986. Syllogeus No. 58. National Museum of Natural Sciences, Ottawa. 662 pp. Free.

This volume contains 77 papers, a panel discussion, and 32 abstracts presented by 157 authors during a symposium held in Ottawa, Canada, in August 1984. The organization of the proceedings is convenient; the four symposia and panel discussion are presented in their order of occurrence at the conference, followed by 42 contributed papers, 18 posters, and the abstracts, which are arranged alphabetically by author. The proceedings conclude with a list of the registered 116 participants from 27 countries, an author index, a taxa index, and a subject index.

Each paper was reviewed by a session chairman, and when necessary by another reviewer. Except for two papers and an abstract in French, all papers are in English. Unlike many proceedings which represent simply compilations of camera-ready copy, the edited manuscripts were typed with a single word processor, resulting in a uniformity of style. Perhaps the too frequent misspellings are a result of this massive undertaking, however, the editors are still to be commended for producing such a readable product from the writings of so many authors whose primary language is not English. A minor quibble, perhaps, but I do not understand why the posters were separated from the contributed papers, as their formats are not distinguishable in the proceedings.

Like most symposium proceedings, the quality of the papers is a mixed bag. The symposia are well arranged and stimulating; I particularly enjoyed the panel discussion of copepod phylogeny. The large number and diverse offerings of the contributed papers and posters insure that everyone, copepodologist or not, will find several items of interest. To those who might disdain such a large collection of contributed papers for lack of integration, I counter by offering that this collage by a large portion of the world's foremost copepod researchers has generated a snapshot of the current state of copepod knowledge. The indices insure that the volume provides a current and comprehensive reference for all things copepod.

THOMAS C. SHIRLEY

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A Birder's Guide to Trinidad and Tobago

By William L. Murphy. 1986. Peregrine Enterprises, College Park, Maryland. 124 pp., illus. U.S. $12.95 + $2.07 shipping and handling.

The first printing of this small birding guide (a second printing, virtually similar to the first appeared in 1987) contains a mass of information about birding in those southern Caribbean islands. The long introduction deals with the geography of the islands, the general natural history, the climate, and provides much detailed information about travel in the islands (lodging, transportation, driving, immigration, and customs, etc.). The guide does not say much on how to proceed to the islands but gives the reader an enormous amount of information on how to get around once you are there. It could also be very useful to anyone planning a trip, even to those who are familiar with the islands. The information is well organized and accurate.

The other parts of the booklet cover mainly birding in the islands. The author gives good descriptions of the main habitats, regions to visit, and sites of interest for bird watching. An extensive list of "Specialties of Trinidad and Tobago" introduces the reader to the species of particular interest to birders. The last sections of the work vary greatly in length and usefulness but I found the annotated bibliography extensive and well researched. In addition, the list of scientific and common names of birds of the area, their seasonal distribution, and the index are particularly useful. There are over 35 figures in the text, habitat photographs, and practical maps which will facilitate the location of points of interest.

The booklet appears to have been computer generated in a camera ready format but the printed results are disappointing. Hopefully, the second printing (I have not seen it) is a production of better quality! However, the non-professional appearance of the presentation should not detract the reader from extracting the valuable information contained throughout the booklet although it may frustrate many of them considering its relatively high price.

In spite of these few critical remarks, I highly recommend this work to anyone travelling for pleasure or specifically to watch birds in Trinidad and Tobago.

HENRI OUELLET

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Mammals of Arizona

By Donald F. Hoffmeister. 1986. The University of Arizona Press and The Arizona Game and Fish Department, Tucson. 602 pp., illus. U.S. $49.95.

Naturalists who have had the good sense to visit Arizona, as well as biologists with the opportunity to study there, will all attest to the fabulous diversity and beauty of landscapes and habitats, and the remarkable abundance of plant and animal species found in this region. In fact, this state claims 139 native species (including humans) and 7 non-native species (a total of 211 subspecies) of mammals, a number matched by few other places in North America.

Southwestern mammals had intrigued a young college student, Donald F. Hoffmeister, who began collecting and preparing specimens in California, and later in Nevada where he assisted Dr. E. Raymond Hall in the preparation of his treatise on the mammals of Nevada. In the 1940s Hoffmeister turned his attention to the mammals of Arizona, ". . . for they were poorly known and no one was doing anything to rectify this situation." So began an investigation of the mammalian fauna of this corner of the United States, which was to last for 35 years. It would involve extensive field collecting, with the aid of Woodrow and Lois Goodpaster, numerous graduate students, and professional mammalogists, and the massive accumulation of data leading to this definitive study on Arizona mammals (a previous book was E. Lendall Cockrum's *The Recent Mammals of Arizona* published in 1960).

In a country which pioneered modern methods of studying mammals, this book stands out in its scope and depth of treatment. A total of 42 278 specimens from 10 437 localities was examined. A large percentage of this material is housed at the Museum of Natural History, University of Illinois at Urbana-Champaign, where Hoffmeister served as Director and Professor for most of his career. This is a large book — the 602 pages and 21 by 28-cm format permit good-sized illustrations and the inclusion of copious text and data. Numerous tables of external and cranial measurements, and technical charts are obviously directed at the serious student of mammalogy. Detailed keys are provided throughout the book — a useful feature, for many of the smaller species are difficult to distinguish, even by a professional mammalogist. Over 500 illustrations (of consistently high quality) augment the text, adding greatly to the book's relevance and interest to the lay reader. The liberal use of black-and-white photographs, many by W. W. Goodpaster, Bruce J. Hayward, Arizona Game and Fish Department, and the Arizona-Sonora Desert Museum, show most species and their habitats. (I didn't miss the use of color photography, typical of most recent mammal books). Since many mammals are secretive, these habitat photos with captions listing associated species provide interesting information on the ecology of mammals typical of Arizona's desertscrub, grassland, chaparral, woodland, riparian forest, montane forest, and alpine meadow. Another fascinating feature is the use of vegetation-substrate-elevation profiles which graph the distribution of mammals within these zones. The great variety of habitat types (often in close proximity) and the extensive partitioning of mammal species within them, offer an insight into why Arizona is so biologically rich.

The introduction to the book highlights fossil mammals, early mammal collections and researchers, methods, and museums with significant holdings of Arizona mammals. Other preliminary chapters are devoted to game animals and endangered species, diseases transmissible to humans, environmental factors, and adaptations to desert conditions. Here we learn that in spite of the desert's harsh living conditions and sparse cover of vegetation, the small-mammal fauna may be remarkably diverse and abundant. Use of underground burrows during the day, strict physiological conservation of water, aestivation, and the usual availability of seeds in the soil (often 26 000/m^2) are important factors in desert survival.

The chapter on biogeography is particularly instructive for naturalists. It summarizes, with photographs and detailed maps, the complex distribution of major plant communities throughout the state. A two-page table outlines the presence or absence of 130 species of mammals in 13 vegetation types. Faunal relationships are followed by a checklist of Arizona mammals.

The bulk of the book consists of the species accounts arranged by order, family, genus, and species, each with specialized keys for identification. Photographs and drawings of skulls, teeth, and bacula complement the keys and will be used mostly by serious students. Each account begins with a description of the range, accompanied by a map with specimen localities numbered to correspond with a detailed listing of records of occurrence, which also provides the number of specimens and the museum where they are housed. This complete information is seldom offered by other books on mammals, and is of great value to researchers. Technical descriptive sections on diagnosis and comparison are followed by remarks and life history, which general readers will find most interesting. Subspecies are treated in the same format. Final Chapters list introduced and hypothetical species, plant names, type localities of mammals, a comprehensive bibliography (almost 600 entries), and an index.

This is, without a doubt, the most comprehensive book yet produced on the mammals of a state, province, or geographic region in North America. Both amateurs and professionals will find the book fascinating and useful. It is essential reading for anyone contemplating a trip to the American Southwest.

ROBERT E. WRIGLEY

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The Breeding Bird Survey: Its First Fifteen Years, 1965-1979

By Chandler S. Robbins, Danny Bystrak, and Paul H. Geissler. 1986. Resource Publication 157. Fish and Wildlife Service, United States Department of the Interior, Washington. 196 pp., illus.

The Breeding Bird Survey (BBS) is a cooperative program to collect information on breeding birds across North America. It is jointly sponsored by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service. Volunteers collect information on birds in the breeding season by running road transects that consist of 50 three-minute stops that are each 0.8 km apart. The observer listens and watches for all birds at each stop.

The BBS was started in 1965 and is still operating each year. The theory behind the project is that measurement of the breeding bird populations each year across the entire continent that is road accessible should provide a basis for determining future status and distributional changes.

The book by Chandler Robbins and his associates summarizes the data from the first 15 years of the project. Population trends for 230 species are included. Each species is discussed in written and chart form. For 170 species, simple graphs that show the annual population changes are presented. For a few species there are spectacular density maps that cover the U.S. and southern Canada.

The end of the interpreted data is 1979, which is seven years before the publication. No reasons are given for the choice of this early date or the seven year delay.

It is excellent to see a truly international approach in this book. The bird populations across all of the lower 48 states of the United States and all of populated Canada, in which road transects can be run, are mapped. Bird populations do not recognize human political boundaries and this report ignores such boundaries.

For analysis purposes the continent has been divided into a number of useful physiographic regions. The methods used to choose the boundaries are not discussed but they appear to represent dominant vegetation zones. In Canada, they follow well-known forest classification systems.

The book is printed on good quality paper with a number of excellent full colour maps. These maps of North America show data on: mean number of individuals per route, species diversity, mean number of species per physiographic regions, and mean number of species per Christmas Bird Count. To my knowledge, with the exception of the CBC map, these maps provide information of a breadth and significance never before published. For the first time, we have continent wide species diversity maps that are based on solid data. Earlier attempts, by necessity, were based upon scattered sources and lots of conjecture.

The density maps for each species are superb and interesting. Each map shows isopleths of the number of individuals of a species per BBS route. They show detailed patterns of distribution and density of a type never before possible. The areas of highest density are shown darkest and progressive lighter shades of grey show lower densities in an intuitively recognizable fashion. For example, over 100 Mockingbirds per route in the Rio Grande Valley show as a black area. Correspondingly, in the southwestern counties of Ontario the less than four birds per route show as a very light grey. Between Ontario and Texas one finds progressively darker bands as the population density increases. The only problem with the maps is that, unfortunately, the authors did not provide density maps for all species.

The BBS survey method is not an appropriate inventory system for all species. Species that are not sampled well include those that are rare, very local, nocturnal, high elevation, high latitude, or colonial seabirds. The authors recognized and discussed these limitations.

Many significant trends were detected. Common Flicker populations are decreasing in the east. The Bewick's Wren has almost disappeared in the east. Warblers and vireos have increased, probably due to high spruce budworm levels. The abstract discussing such changes is over two pages long. Each of the 230 species discussed has a useful summary.

This is a book that will take a long time to read and digest. It is full of data but it is not tedious to uncover. For those interested in avian population trends in mainland North America it is the book to read.

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The Philosophy and Practice of Wildlife Management

By F. F. Gilbert and D. G. Dodds. 1987. R. E. Krieger Publishing, Malabar, Florida. xi + 279 pp., illus. U.S. $24.50.

Among several books used at the university level to teach wildlife biology students about their craft, none really prepares them for the "real world". As a result, few graduates are ready to meet the political and social realities that go hand in hand with working as a wildlife manager. The authors have provided a broad basis of cases and discussions of biological premise to help the reader understand many of the problems and controversial issues faced by modern resource agencies. The text is written in a refreshingly candid style and is thoroughly readable.

The book is organized into eleven chapters. The first two deal with evolution and administration of wildlife management agencies in Canada and the United States, and some of the underlying philosophy and values towards wildlife managment. Chapter 3 examines some aspects of biology important in management considerations and the fourth chapter is a precis of management tools. Habitat management, case examples of managing particular species, preserves, and endangered species management are examined in four subsequent chapters. A chapter is devoted to environmental impact analysis. The book closes with a discussion of some international concerns and a look at where the wildlife management should increase efforts in the future. A short section of suggested readings is included at the end of each chapter. In order to obtain the most from the book, it should be read at the third or fourth year level of university after or concurrently with courses in physiology, genetics, ecology, and wildlife management.

This is so different a book that I think any university course in wildlife management ought to consider it as required reading. Overall, the authors have accomplished their goal and reading the book will stimulate students to ask a number of hard questions which could form the basis for some interesting guest lectures by government management biologists. In Chapter 6, for example, there is a rather factual and somewhat scathing report on the management and decline of Black Ducks (*Anas rubripes*) in eastern North America. The student readily becomes aware of the reality of political interference and social concerns in attempting to manage wildlife. The authors have done an excellent job in assimilating the science and politics involved in all of their case studies and have chosen some particularly informative examples. I was particularly impressed by Gilbert and Dodd's decision to include a chapter on environmental impact assessment. Recent wildlife graduates often are employed in that field without any prior exposure to current methods or theory. The final chapter, which discusses influences on wildlife management and future needs in education and management, is particularly useful in directing a student's interests to areas which will help him or her to formulate a career path.

As a general statement, I liked the book and feel that it has a lot to offer but would suggest the following criticisms. The book is written from an extreme utilitarian point of view with virtually no value ascribed to wildlife unless it can be used for something and managed to that end. I think a more holistic approach to include so-called non-game species and non-consumptive values of wildlife would help considerably in the portrayal current management efforts. As an example, game ranching is presented as a management option without balancing the issue with counter arguments. In a similar vein, the authors speak at length about wildlife declines without offering the case for several species which have increased as a result of altered habitats and proper management regulations, for example Moose (*Alces alces*). Chapter 3 is somewhat loosely organized and it is difficult for the reader to gain any sense of logic to the flow. The concept of "minimum viable population" modelling could be introduced in discussions of endangered species management. In Chapter 8, the suggestion is made that poaching be legalized (because it is occurring anyways) in areas of Africa as an aid to reduce problem wildlife populations; any of us who have been involved in wildlife management will disagree rather adamantly!

Wildlife management is a changed field over what it was only a decade ago. Increased pressures on the land base and consequently on wildlife habitats, a more politicized public, rapid communications, and a large body of research have combined to make wildlife management an intricate science. This book goes a long way towards fore-arming students with a sense of those complexities.

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Fur Seals — Maternal Strategies on Land and at Sea

Edited by R. L. Gentry and G. L. Kooyman. 1986. Princeton University Press, Princeton. 291 pp., illus. U.S. $14.50.

This comparative study of six species of otariids (five fur seals and a sea-lion) grew out of the first author (and editor's) behavioral studies of adult female lactating Northern Fur Seals, *Callorhinus ursinus*, ashore at the Pribilov Islands, and the development by and for the second author of a time/depth recorder which could be strapped to the female fur seal before it went to sea to forage, and recovered when it returned to the pup. It records on a time base, time in transit to and from feeding grounds, depth and frequency of dives, and time of rest between "bouts" of dives, statistically defined. For this species, energy expenditure at sea and on land and energy transfer to pups were also measured using radioactive tracers. Collaborating with an international team of 12 other investigators, the principal authors took their recorder to colonies of the five other species, living in habitats ranging from sub-Antarctic to tropical with high marine productivity.

High latitude otariids prove to show a short (four month) intensive lactation with rich milk fed through the short summer. Near the equator lactation is prolonged to two years or more, and since an annual pregnancy is the rule in otariids, females of the tropical species may suckle a new pup and a yearling simultaneously. By chance, the study of South American Fur Seals, *Arctocephalus australis*, on the Peruvian coast took place at the height of the El Nino/Southern Oscillation of 1983 when food was scarce, and mortality of pups and yearlings was indeed high. These pups, however, learn to go to sea by degrees. In contrast, the reliably-fed, high-latitude pups go to sea en masse by themselves in autumn without experience. Their mortality in the first winter of life may be high. The Galapagos Sea Lion, a race of the well-known *Zalophus californianus*, feeds at depths greater and closer to the coast than the Galapagos Fur Seal, *A. galapagoensis*, and also by day; all fur seal females feed nocturnally or at evening and morning, presumably on fish or Crustacea associated with the biological scattering layer which ascends at night; they may dive to 200 m. At the Pribilov Islands, fur seal females leave their pups for longer periods to feed at sea the further the colony is from the Continental Slope, but at one island the time has not changed over the years even though the fish food base has received heavy commercial fishing during this time. Using the time-depth recorder alone, however, one cannot estimate the quantity of food eaten by a female fur seal. There is much more in this series of 13 papers on the behavior of individual species, plus introduction, methodology, discussion, and conclusions.

Coming from very much the same team, just afterward, is another multi-authored work which gives full background biology of all the fur seal species and subspecies: *Status, Biology and Ecology of Fur Seals*. Proceedings of an International Symposium and Workshop, Cambridge, England 23-27 April, 1984. NOAA Technical Report. NMFS 51. *Edited by* J. P. Croxall and R. L. Gentry. June 1987, 212 pp. (Distribution Centre, Black Horse Rd., Letchworth Herts, U.K.).

All species of fur seals have increased in population to varied degrees in recent decades, some from virtual extinction, and some (like the Antarctic Fur Seal, *Arctocephalus gazella*) spectacularly and even embarrassingly, since dense colonies may kill land vegetation. Up to three species have been recorded at one island, and the evolving ecology will make fascinating reading — as will further studies on the life-history strategies outlined in the first book.

D. E. SERGEANT

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Restoration Ecology: a Synthetic Approach to Ecological Research

Edited by William R. Jordan III, Michael E. Gilpin, and John D. Aber. 1977. Cambridge University Press, New York. ix + 342 pp., illus. U.S. $39.50.

At the present time, ecology is unable to predict the structure and function of severely disturbed natural communities and ecosystems. It is the consensus of the 27 contributors to this book that a synthetic approach to ecology may improve our understanding of the how's and why's of ecological functions enough to make ecology a predictive science. The opportunity to practice such a synthetic approach is offered by the restoration of severely disturbed sites such as strip mines, polluted lakes, and badly eroded cropland. These sites often lack many basic ecosystem elements like soil, plants, and animals. It is the task of the restorationist to synthesize a new functioning ecosystem by replacing these basic elements at a much faster rate than would be accomplished by natural succession.

During the restoring of "natural" communities, ecologists will have many chances to test basic ecological principles if properly designed experiments can be incorporated into restoration projects. This book contains many examples of such experiments — both existing and proposed. The examples include tests of theories about succession, competition, species diversity, landscape ecology, and mycorrhizal relationships. Since many restoration projects involve sites where both the soil and the vegetation have been removed, there are opportunities for ecologists to control one or more environmental factors during the restoration process. This permits the evaluation of other factors that are usually confounded by the factor to be put under control in the experiment. For example, a uniform depth of soil could be placed on a hilly strip mine site. Then other factors that influence vegetation patterns could be studied more easily without the confounding effect, different soil depths.

While most of the book's contributors were very enthusiastic about the chances that restoration projects offer to the development of ecology as a science, several contributors pointed out some important considerations and limitations. The goals of the theoretical ecologist may require large-scale manipulations, but these may stall the biotic community's progress toward the goal that the restorationist is trying to achieve. Consequently, ecologists will have to design their experiments to mesh with the plans and goals of the restoration project. On the other hand, the results of ecological experiments may lead to improved restoration techniques that will save large amounts of time and money.

The restoration of prairies, forests, and lakes are included in this book. The editors wanted a book about both the techniques of restoring ecosystems and a technique for doing ecological research. They obtained a mix of both from their contributors, but the emphasis was definitely on the latter. This slant was a result of the majority of contributors coming from academia and the minority coming from institutions responsible for restoration activities.

The contributors from academia were well qualified and experienced with restoration efforts. However, a greater representation of contributors from the restoration and reclamation profession might have resulted in a vigorous discussion of the real possibilities of incorporating synthetic ecological research into restoration projects and programs. For example, from my personal experience with strip-mine reclamation in Montana, the possibilities for such research may not be as limitless as some authors suggest due to the pressure for the quick and complete restoration that state and federal reclamation laws impose upon the restorationist.

Nevertheless, this book is a must for serious plant ecologists since it points the direction in which many ecologists are headed in the crusade to make ecology a predictive science. The well-written, fast-reading chapters reflect the contributors' excitement over the possibilities presented by a synthetic approach to ecology. If this approach yields predictive capabilities, ecologists will be able to suggest more effective solutions to the many ecological problems created by modern society. The ability to do so becomes more valuable with each new ecological disaster.

BLAINE H. M. MOOERS

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Adaptive Strategies and Population Ecology of Northern Grouse

Edited by Arthur T. Bergerud and Michael W. Gratson. 1988. University of Minnesota Press, Minneapolis (Canadian distributor Beaverbooks, Markham, Ontario). xxiii + 809 pp., illus. Cloth $86.95; paper individual volumes $26.50 each.

In this hefty two-volume book, the fascinating group of birds which include grouse, ptarmigans, and prairie chickens receives a detailed and synoptic examination. The researchers are from various locations in North America, as well as Iceland and Norway, with the series editor responsible for seven of the 16 chapters. The first 11 of these provide population studies on selected species, while the last five focus on a theoretical synthesis of the sociobiology of the tetraonids. The population studies are organized by the three chief types of habitat: forest, steppe, and tundra. Among forest species, populations of Blue Grouse display linked differences in behavioural and demographic characters. Transplantations of birds from populations differing in critical features reveal a heritable basis to the behavioural phenotypes for dispersal. In its aggressive behaviour the Ruffed Grouse shows individual differences, which are of increasing interest to behaviourists and ecologists. This grouse is also colour dimorphic, with demographic consequences. As in other species, its feeding efficiency is compromised by the need to watch out for predators. Among steppe species, telemetry of Sharp-tailed Grouse provides details of their leks, home ranges, and movements, but no evidence of sharing information on food sources. Similarly, telemetered Greater Prairie Chickens show fidelity to leks and nests. Recent work on mating in Sage Grouse invalidates earlier claims for the existence of dominance hierarchies among the males of a lek, and demonstrates how females choose their mates based on behavioural differences in fighting and strutting. Among tundra species, the breeding behaviour of White-tailed Ptarmigan includes adoption of lost and orphaned chicks by hens. As in other species, whether such adoptions are adaptive is most unclear. Rock Ptarmigan in Iceland show a 10-year cycle of abundance, but available evidence does not elucidate the basis of these dynamics. In British Columbia, Willow Ptarmigan were scrutinized for their winter survival and spring breeding. The finding that territorial birds which are removed are not all replaced implies the absence of "floaters" found in many territorial species. In insular populations of this species in Norway, the causes of the changes in production and breeding are not clear, and the likeliest mechanism, involving plant production and voles, may be operative in these populations only. Such conclusions illustrate the difficulty of achieving generality in population biology.

The theoretical synthesis includes a population model, three lengthy reviews of tetraonid biology, and management issues. A genetic explanation for population cycles is produced as a one-locus model based on a diversity of data and supportive of the hypothesis put forward by Dennis Chitty involving behavioural polymorphisms. On a comparative basis, the differences in predation pressures across habitats is argued to have led to the array of mating systems from the monogamy of Willow Ptarmigan through dispersed polygyny to clumped polygyny as in the leks of Sage Grouse. A similar comparison of patterns of mortality and breeding examines mate choice, chick survival, and polymorphisms in spacing activity. The population dynamics of grouse, cyclic or not, pivot on demographic features, female choice, and the density-dependent selection of behavioural phenotypes, while their management requires attention to hunting, space, cover, and predation. Each chapter is helpfully summarized, there are copious figures and tables of data, and a subject index by species. Comprehensive references are included.

This book can scarcely fail to tell you everything that you ever wanted to know about the population biology of grouse, and it is impossible not to admire researchers who can report cheerfully that at -40 degrees the weather was "not particularly severe". Some of the accounts are almost exclusively descriptive and the resulting limited data cannot distinguish different possibilities. However, the best of the chapters are broad and interpretive, with behavioural, ecological, genetical, and hormonal aspects investigated through the use of a wide variety of research techniques, both observational and experimental, including behavioural tests (such as reactions to various stimuli), population manipulations, telemetry, and modeling. While there are occasional peculiar statements, the bulk of the discussion is lucid and sensible. Especially valuable is the clear distinction of proximate and ultimate causation, and the contrasting of alternatives in the interpretation of results, such as experiments in which adult males are removed indicating that sexual selection, not delayed maturation, is responsible for nonbreeding in yearling males. Much attention centres on the cyclic dynamics of many populations, a phenomenon in many species of long standing interest to population biologists. Not surprisingly, Chitty's hypothesis is examined closely at several points and generally supported. Additionally, other causes, such as the switch-over of predators from cycling rodents, are carefully considered. Avenues for further research are also indicated, such as the function of courtship interruptions in Sage Grouse. Overall, this book is fairly specialized, but provides good reading for all those interested in tetraonids or population biology generally.

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Grand Canyon Birds; Historical Notes, Natural History, and Ecology

By Bryan T. Brown, Steven W. Carothers, and R. Roy Johnson. 1987. University of Arizona Press, Tucson. 302 pp., illus. U.S. $19.95.

A book dealing specifically with the birds of the Grand Canyon has made its appearance. It is a pleasant change to read of an area with boundaries that are natural, not political. However, the potential of this book to be an interesting account of such a unique area was only partly realized.

The book is divided into three sections. The first, which is broken down into four chapters, is an account of the ecology of the Grand Canyon with respect to its birdlife. The history of ornithological study in the Canyon is presented, along with an analysis of the habitats and associated birdlife, a description of how the birdlife has changed over the past thousands of years, and a discussion of the birds of the Colorado River.

The second section contains a checklist of the 303 species followed by a general account of each species. This section accounts for about half of the book and would be a minor disappointment to an avid birder. It lacks detail, for example, in the account on the White-throated Swift the birds return in "early spring" and leave in "late fall", chronological data on which one would not want to base a trip. Most of the accounts contain similar general information at the expense of precise dates and numbers which would be of greater value to a visitor.

The third section contains three appendices, one of which deals with where to find birds in the Grand Canyon. The book lists 46 areas of significance, yet describes in detail only four of the most easily accessible. Even those four are lacking in information of what can be seen at what time of year. Therefore the site guide portion of the book should probably have been elevated in status and greatly expanded for the benefit of people travelling to the Grand Canyon.

Overall, *Grand Canyon Birds* is a good, general review of the avifauna of a biologically interesting area. This book is written from the viewpoint that birds are part of the environment. This extends the appeal to those with interests beyond birds. It is a good book to read if you are planning a trip to the Grand Canyon, but serious birders should use it in conjunction with *Birds of Arizona* or the *Annotated Checklist of the Birds of Arizona.*

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The Birds of the Creston Valley and Southeastern British Columbia

By Robert W. Butler, Brian G. Stushnoff, and Edward McMackin. 1986. Occasional Paper Number 58, Canadian Wildlife Service, Ottawa. 37 pp., illus. Free.

The importance of this slender book is evident neither from its size nor its title. It contains a very good annotated regional list of birds as well as an account of large increases in bird populations nesting in marshes which are my candidate for Canada's most successful venture into wildlife management. In fact, information from these marshes in the Creston Valley Wildlife Management Area (6880 ha) dominates this publication because of the variety and abundance of its birds, and because of the detailed studies attracted to that abundance.

As noted by the authors, this list is based on three earlier lists, one compiled by W. B. Johnstone and published in 1949 by the British Columbia Provincial Museum in its Occasional Paper Number 7, and two by J. A. Munro published by the same museum, one in 1950 as Occasional Paper Number 8, the other a supplement in its Annual Report for 1957. These papers enable interesting comparisons of bird populations then and now.

In the report under review, recent studies of several species enable enlarged species accounts for Great Blue Heron, Tundra Swan, Canada Goose, Osprey, Tree Swallow, and Cliff Swallow. Notable species included in the list are: Clark's Grebe which has recently discovered the stabilized marshes; Wild Turkey (introduced); Forster's Tern, first seen in 1970 and now a nester in the province's only colony; and 23 records of the Blue Jay.

Censuses of passerines were undertaken in four broadly defined kinds of habitat in the Creston Valley. Numerical results are presented in a table. Another includes the current status, in general terms, of those land bird populations which show marked changes since Munro's assessment of 1950, before the Creston Marshes were diked. A third table repeats this comparative process for water birds, this time showing numerical census counts and estimates as the more recent data. Impressive differences are evident in the last table. For example, the Pied-billed Grebe increased from "suspected breeder" to "50-110 pairs in summer", and the Ring-necked Duck from "no nest records" to "105 pairs in summer."

The dramatic increases in nesting water birds are a result of diking much of the marsh area and then controlling water levels. The original condition before diking was extensive marshes covering much of the delta formed by the Kootenay River entering Kootenay Lake. A number of species, mainly grebes and ducks, attempted to nest each year as the marshes warmed in May, only to have their nests swept away by the floods of June. Most of the drainage basin of the Kootenay River is in high mountains which accumulate deep snow through winter. These cold heights have a late spring thaw contrasting with the much earlier arrival of spring in the valleys, many of which are in rain shadow so accumulate little snow. While spring creeps north into British Columbia along the valley floors in April and May, it creeps up the mountains to reach the deep snow under forests at high elevations in June and July. As a result, rivers in the major valleys seem to rampage surprisingly late in the year. On Creston Flats these annual floods severely limited the nesting successes of birds in the marshes. Now this natural limitation is eliminated. Dikes keep floods out of the marshes as well as adding the ability to manage marsh vegetation by controlling water levels as wanted. The result has been dramatic increases in nesting birds: grebes, herons, ducks, Ospreys, American Coots, Black Terns, and no doubt others less easily observed.

Managing the marshes has been largely a game management venture, a cooperative effort of the Canadian Wildlife Service, British Columbia's Wildlife Branch, and private interests funded mainly by hunters. As in so many places throughout North America, in the Creston Valley the enthusiasms, dedications, generosities, and political clouts of the hunters among us have saved rich wildlife habitat for hundreds of species of wild plants and animals.

The result near Creston is one of Canada's unsung conservation successes. This book now offers all the notes needed for the song.

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Saving America's Wildlife

By Thomas R. Dunlap. 1988. Princeton University Press, Princeton. 222 pp. U.S. $24.95.

In *Saving America's Wildlife*, Virginia Tech history professor Tom Dunlap seeks to explain America's changing attitude towards wildlife preservation in the twentieth century. He does so by focusing on the fate of the wolf and its transformation from cruel, murderous predator to today's revered symbol of the wilderness. It is a fascinating story — largely because, as Dunlap ably demonstrates, it was not only the new science of ecology but also a new public appreciation of the wilderness which led to the "rehabilitation" of the wolf.

In the early twentieth century, Dunlap describes how prominent American natural scientists, such as William Hornaday of the New York Zoological Garden, despised the wolf because it killed the very animals which early conservationists wanted to protect. It was consequently seen as man's role to manage the environment by wiping out this scourge and thereby making the natural world safe for so-called "desirable" animals. This attitude persisted until the mid-twentieth century when the development of ecological principles and modern wildlife management techniques pointed the way towards a new understanding of the wolf. It was a slow process though. Part of the problem was that little was known of the wolf and its habits. Nor was it easy to study this animal. Thus, it was not until after the Second World War that the wolf's crucial place in the ecosystem was realized.

Saving America's Wildlife suggests that this new scientific attitude towards the wolf did not in itself bring an end to government predator control programs; President Richard Nixon's signing of the 1973 Endangered Species Act was more a response to public pressure. Dunlap argues that Americans at the turn of the century identified the wolf with the country's untamed wilderness and would have regarded any attempt to save the animal as a repudiation of their pioneer past. Predator control was seen as a good thing. But as North Americans became alarmed about threats to the environment in the early 1960s, the wolf acquired a new image as the symbol of the unspoiled wilderness. "When the wilderness had been feared, the wolf had been fearsome," Dunlap observes. "As the wilderness became wonderful, so did the wolf." In the process, extermination gave way to preservation.

A widely researched and extremely literate study, *Saving America's Wildlife* emphasizes the important link between wildlife management techniques and public attitudes to wildlife. It also draws attention to the leading role which women played as wildlife advocates in the 1960s and 1970s. Finally, it explains why the United States national parks service is looking today to its Canadian western counterparts for help in trying to reintroduce the wolf to some of its former range.

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The Encyclopedia of Animal Biology

Edited by R. McNeill Alexander. 1987. Facts on File Publications, New York. 144 pp., illus. $37.95 in Canada.

One more in the Facts on File Encyclopedia series, this book is an attractive, brief presentation of essential facts on a variety of topics in animal biology. A short table of contents shows the standard pattern of study of animals beginning with a review of the Phyla progressing through notes on cellular biology to identifying different organ groups, and ending with reproduction and development. Hints about behaviour and ecology groupings are contained within the text, though the topic of ecological communities is never formally addressed. The editor engaged many experts from around the globe to write the various chapters and each chapter shows a different area of expertise within the field of biology. With the exception of C. Barker Jorgensen of Denmark, all of the contributors are from the English-speaking world.

Probably the strength of the book is its photographs and colour diagrams. While reading, one is constantly encouraged to leave the text and pursue the diagrams as each new page is examined. High school students who looked at the text generally agreed that it was an attractive book: they wanted to look at it further and to use it as a reference for projects and assignments. All who read it agreed that the detail was insufficient for the book to be used as a course text. Students felt it could only be used in conjunction with other references. Many students felt that the book was written beneath their academic level, a compliment to the authors for making the book readable. Some topics of physiology examined in the book are actually beyond the high school level but easily missed by a casual reader because of the brevity of the text.

A surprisingly good index and glossary give access to the topics and explanations very quickly. The diagrams help to image the topic quickly; in a secondary reference this is helpful. However, when trying to correlate material from the text with the diagrams, one finds the information in the text is very sketchy and does not add very much. The photographs are many and varied supporting the text in many cases with coloured scanning electron micrographs, full-colour photo-micrographs, and some startling close-up shots of insects and mammals. Many other photographs are included; they show other interesting shots of various members of the animal kingdom, but chosen less for their support of the text and equally for their photographic merit of action of different kinds of animals.

Actually reading the text took a long time. Preliminary time was spent using it as a picture book and reading the diagrams, picture descriptions, and other figures. But attraction to browsing is the strength of the book and its utility as a source book for those building a home library of biology, or providing an additional reference to a school library.

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Handbook of Animal Diversity

By Richard E. Blackwelder and George S. Garoian. 1986. CRC Press, Boca Raton, Florida. 555 pp. U.S. $225.

I am not hostile to the purpose or subjects of this summary of morphological and functional zoology, which seeks to redress the fact that "zoology courses often are forced to serve other goals than to make known the animal kingdom". I work on macroscopic animals, using few tools, except computers, that were not available to Darwin. I attempt reviews of diverse organisms, I suspect that a life not dedicated to invertebrate zoology is, to some degree, misspent, and two of my cousins are due to polyembryony. As a careful synthesis of the older and most recent literature, this book could be a marvel of careful scholarship and a ponderous delight. It tries to "restore the balance to the word diversity, by its constant repetition, . . . by tabulating the diversity that has been assembled, and by providing a framework into which others can fit the no-doubt-large number of cases of which the authors are ignorant".

The repetition comes as many subjects, including blood, skeletons, sex, and the absence of sex, receive several similar page-long treatments in different chapters. Polyembryony is defined or treated as a novelty 28 times, and endless attacks are made on the outdated presumption that only simplifying generalizations are important to biology. References are listed at the end of each chapter, and Hyman's *Invertebrate Zoology* appears 20 times, in nine distinct formats.

It would be hard to use this as a handbook. Neither running heads nor section heads nor table numbers mark the chapter on the page. The index has a spaciousness consistent with its failure to include many terms that are in the tables or text. Most tables are untitled lists of vague or narrow items in alphabetic or taxonomic order; they are rarely comprehensive, and they are not listed in the table of contents. A table of only seven terms for sexual dimorphisms includes "pollard" and "free martin"; a list of molluscan "tissue products" which is said to exclude "hard parts" includes only shell and blood plasma, though crystalline styles, radulae, slug slime, hinge ligaments, and periostracum are mentioned elsewhere. A table that is said to have four items has seven.

The reader is supposed to "often forget" that parasites move about, that whale zygotes are small, that animals other than mammals are viviparous, and many other commonplace facts. The authors seem to have forgotten, herpetologically, that most amphibians have no epidermal hard parts, that snakes do not shed their skins "seasonally", that this process is termed ecdysis, that some salamanders autotomize their tails, that stomach-brooding frogs are Australian, that Leatherback Turtles are warm-blooded, that "so-called horned toads" are lizards, that reptiles and birds have meroblastic eggs, that few reptiles fly, that snakes feign death, that incubation temperature determines the sex of turtles, and that some vertebrates are obligately parthenogenetic.

They seem willfully ignorant of modern and quantitative biology, of the genetic code, the difference between procaryote and eucaryote cells, genetic polymorphism, phylogenetic reasoning, biochemical systematics, heterochrony, cell biology, and behavioural ecology. Allometry is defined as the "condition of having large and small forms together" and animals are said to store lead and radium "for later metabolic use." The authors do not understand that biological generalizations are not brittle hypotheses vulnerable to exceptions, but modal themes in the histories of independent lineages, so that "laws" like the cell theory are superceded by deeper understanding of their mechanisms. They rarely consider the causes of diversity, and seem surprised that natural systems do not fit simple artificial classifications.

Biochemists are attacked for their lack of interest in diversity. The biochemists I know are crazy about diversity, and require a constant supply of diptera, anurans, rodents, crayfish, reptiles, gastropods, and other animals. If they were to look up their interests here, what would they find? Freeze-tolerance: nothing. Supercooling, ice, low temperatures: nothing. In the one table on hibernation and dormancy no adaptations to freezing are mentioned, and the hibernation of amphibians and reptiles is lumped with the urea-recycling hibernation of bears as the "Lethargy of Carnivores." Brumation, the term specific to poikilotherm hibernation, does not appear.

Most amazingly, there are few citations to the literature and the references are mostly generalizing textbooks. Two-and-a-half times as many references date from the period 1951-1967 as from 1970-1986. No one is thanked for reviewing the manuscript. This book reads like lecture notes from a course in introductory zoology. As lectures, it would be entertaining and idiosyncratic; as an audaciously expensive book it frustrates the specialist with errors, and misleads the beginner with omissions.

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The Skuas

By Robert W. Furness. 1987. Buteo Books, Vermillion, South Dakota. 363 pp., illus. U.S. $45.00.

The skuas (or in North American terminology, the jaegers and skuas) are a favourite group of many birders and ornithologists. Their subtle but elegant plumage, kleptoparasitic habits, and remarkable grace and speed on the wing astound the observer. Furthermore, the location of their summer breeding areas in remote arctic regions and their elusive pelagic habits at other times of the year add the attractiveness of rarity. Skua fans and others will be pleased to find in this volume the first detailed review of the biology of the family Stercorariidae.

The book covers nearly everything one could want to know about skuas in sixteen clearly written if extremely detailed chapters. A brief introductory chapter outlines the highlights of the following text, then the second chapter presents a history of skua classification. As in the rest of this book, Dr. Furness has done his research thoroughly here. For example, a number of fascinating historical descriptions of skuas going as far back as 1625 are summarized. In the third chapter, the breeding ranges and population size estimates of the six skua species are described. Next, the migration patterns and the timing of migration, moult, and breeding are detailed. In Chapter 5, one of the most interesting in this volume, Dr. Furness reviews the topic of sexual dimorphism in skuas. Unlike most birds, but as in nearly all birds of prey, female skuas are larger than males, the condition known as reversed sexual size dimorphism. The origin of this "reversed" condition has been the subject of considerable controversy among evolutionary biologists. In this chapter, Dr. Furness presents easily understandable explanations of the logic of several hypotheses that attempt to explain the phenomenon and concludes that reversed dimorphism in skuas has resulted from differences in parental care between the sexes: the larger females defend the nest and care for the young while the smaller males forage for their mate and young. The following two chapters present detailed descriptive information about skua behaviour and feeding ecology. A special chapter is devoted to a behaviour characteristic of skuas: kleptoparasitism (foraging by robbing other birds). I was surprised to learn that no skua species are obligate parasites, although some Arctic Skuas (Parasitic Jaegers) forage mainly by kleptoparasitism throughout the year. In the ninth chapter, Dr. Furness reviews the concept of plumage polymorphism in birds and the hypotheses put forward to explain the phenomenon in the skuas. This was the most interesting chapter to me, and epitomizes Furness' ability to explain and evaluate hypotheses from evolutionary biology in a manner easily understandable to non-scientists. In a very logical manner, Furness makes the argument that despite intensive work on the genetics of Arctic Skua plumage polymorphism, not only is the mechanism which maintains the polymorphism poorly understood, but further the genetic model to explain the inheritance of the plumage morphs is unsatisfactory. The following four chapters contain a straightforward and detailed account of the breeding biology of skuas. Chapter 14 summarizes what is known about the presence of pollutants in skuas, and provides an up-to-date and timely review of the topic of pollutants in seabirds in general. Chapter 15 covers the topic "Skuas and agriculture", a title sure to puzzle North American readers. This chapter is Dr. Furness' personal account of the conflict between skuas and local residents of Foula in the Shetland Islands. The final chapter concerns conservation of skuas in general.

What I liked most about this book was the way both the natural history and evolutionary ecology of skuas were combined in a single text, a characteristic that will be stimulating for naturalists, birders and biologists alike. In this respect, *The Skuas* is refreshingly easy to follow compared with Peter O'Donald's 1983 work *The Arctic Skua: a study of the ecology and evolution of a seabird* which despite its title, dealt overly much with complex mathematical models of little interest to the non-scientist. Although it is clear from the text that Dr. Furness' experience with skuas comes mainly from his work in the British Isles, the text is not overly biased towards this area. Studies of skuas from North America and other areas are carefully summarized. The only topic that I found lacking in this book was the identification of skuas. Birders find small skuas (jaegers) in non-breeding and immature plumages a challenge to identify, mainly because of the lack of published information. Similarly the subtle differences among the large skuas, which has resulted in confusion about their taxonomic relationships, pose identification difficulties. Dr. Furness is clearly more an ornithologist than a birder, something I would not want to fault him for, but more information on skua identification would have been welcome. Dr. Furness' text is sprinkled with 100 maps and graphs and 65 tables, which although packed with information, do not overload the reader with data. The book's other illustrations consist of 35 drawings by John Busby and 30 black-and-white photographs. John

Busby's casual style of illustration did not impress me initially, but after studying his sketches I began to quickly appreciate their remarkable realism and appropriateness to the text. This book would be a valuable addition to the library of most ornithologists, behavioural ecologists, birders, and naturalists interested in seabirds.

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The Birds of the Fraser River Delta: Populations, Ecology, and International Significance

By Robert W. Butler and R. Wayne Campbell. 1987. Occasional Paper Number 65, Canadian Wildlife Service, Ottawa. 73 pp., illus. Free.

This book has been needed for years.

The Fraser River has made the largest delta and estuary on the Pacific Coast of Canada, and the seaward portions of that long delta are used on average by 500 000 birds each year, the annual total of feathered users in some years reaching as high as 1.4 million.

About 130 000 water birds winter on the delta with a density of 410 birds per square kilometre of wetland habitat. No other place on the Pacific Coast north of California has such large populations in winter. The abundance of birds using these waters in that season and during migration is internationally significant (as defined by the Ramsar Convention of 1971) for Snow Geese, Green-winged Teal, Mallard, American Wigeon, Canvasback, Greater Scaup, Surf Scoter, White-winged Scoter, Black Scoter, Common Goldeneye, Bufflehead, Common Merganser, Ruddy Duck, Western Sandpiper, Dunlin, and Glaucous-winged Gull. Nowhere else in Canada in winter are populations as large or as dense as those on the Fraser Delta of Great Blue Heron, Black-bellied Plover, Mew Gull, Rough-legged Hawk, Red-tailed Hawk, and Northern Harrier.

The future of all this, however, is bleak. This marvelously productive habitat supporting outstanding bird abundance has been disappearing for over a century, with even those species still abundant today showing obvious declines from former numbers. Less numerous species are clearly on the way out as urban sprawl and industrialization increase the former damage of extensive diking and draining by agriculture. The Fraser now has all the diseases that kill great rivers.

In winter, when most of Canada is frozen for months and most birds have retreated to lower latitudes, this part of the nation is an unfrozen haven for many kinds of birds. In this southwestern corner of British Columbia, the Fraser pours mineral-rich water gathered from a large part of this mountainous province into the Strait of Georgia. A century ago much of its long delta was in shallow lakes and marshes which were extensively flooded every spring, and its tidal estuary had numerous marshy flats among the islands and river channels which complicated its arrival at the sea. Only one percent of these wetlands has been dedicated by governments to perpetuating this rich area of survival for birds in winter, a key area important to water bird abundances over a third to a half of the continent as well as to many land birds.

The book begins with a good account of the delta, its geological history, its climate, the man-made changes that have occurred, the resulting habitats, and their environmental qualities. Among the informative tables are those giving land use areas, the abundance of species of woody plants, and areas of habitat in 1888 as compared with the 1985 condition. Text and tables deal with the numerical abundances of birds, waterfowl receiving the most attention but counts of woodland birds and others being included as well.

Much of the book is given to an annotated list of the delta's birds, in which accounts for 310 species present details on seasonal occurrence, abundance, habitat preferences, and breeding records. For some there is additional information taken from local studies of foods and nesting. These accounts are detailed, ranging in size from about 40 to 750 words. Most species are given about 160. My one man's selection from this list of a few species collectively locating the avifauna of the delta eco-geographically includes Yellow-billed Loon, Brandt's Cormorant, Snow Goose, Eurasian Wigeon, Turkey Vulture, Thayer's Gull, Common Barn Owl, Black Swift, and Bushtit.

This is a remarkably thorough publication, clearly the result of deep digging to find available data, then adding to these the authors' long personal experiences with the delta's birds. It ends with recommendations which are mainly outlines of the lands and waters which must be acquired and maintained for wildlife use if this unique heritage is not to vanish under the advancing city and its industrialization of the river.

As noted before, this book has been needed for years. May it now stimulate appropriate action to perpetuate some of this ecological treasure.

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Birds of the Okanagan Valley, British Columbia

By Robert A. Cannings, Richard J. Cannings, and Sydney G. Cannings. 1987. Royal British Columbia Museum, Victoria. xix + 420 pp., illus. Cloth $37.50 + $3 postage; paper $27.50 + $1.50 postage.

The Okanagan Valley is well known for its variety of birdlife. Nowhere else in Canada can you watch such southern specialities as White-throated Swift, Sage Thrasher, and Black-chinned Hummingbird in the morning and birds typical of colder climates, such as White-tailed Ptarmigan and Rosy Finches, in the afternoon. A book covering the diverse birdlife of this unique region has long been needed. The three Cannings brothers have filled this gap with a most impressive and attractive document. Their shared biology backgrounds and the fact that all three were born and raised in the Penticton area eminently qualifies them to author such a book.

In the preface, the authors outline the book's objectives. Primary among these is documenting the biology of all 303 bird species recorded in the Valley. A secondary objective is to highlight ornithological gaps for the Okanagan and encourage observers to fill these voids in the future. To assess the biology of Okanagan birds, a staggering 126,000 records were examined of which 10 900 were breeding records.

The book is divided into eight major sections. Topics covered include geography, geographical composition of the Okanagan bird fauna, man's historical impact on the environment, historical trends in Okanagan bird populations, a history of Okanagan ornithology, a month by month chronology of Okanagan bird activity, a "how to use this book" section, and the species accounts. Six appendices cover hypothetical species, rejected species, specimens cited, breeding bird survey routes, scientific names of plants and animals, and a gazetteer. At the end of the book is a very complete bibliography.

The geography chapter is an excellent overview of the diverse landscapes and resulting climate and plant communities that make the Okanagan so unique. One surprise to some will be the statements about the extreme south end of the valley. As the Cannings correctly point out, average yearly precipitation from the town of Oliver is around 12 inches thus making this region arid but not a desert.

The bulk of the book, about 320 pages, is consumed with the species accounts. Each species is described in terms of the major fall and spring migrations, habitats, breeding chronology, food, unusual behavior, and enemies. Most species also have a seasonal histogram where numbers of observations are plotted against the week of the year. The colour of these bars indicate whether the records represent breeding or non-breeding records. Bars underneath the histograms indicate nesting and fledgling periods. Some species contain additional graphs of certain categories of sightings, e.g. Christmas Bird Count results.

On balance, I found these accounts well researched, well-written, and very informative, leaving the reader with a good idea of the status and natural history of each particular Okanagan species. The authors have indeed given an excellent summary of the known information about bird species in the Okanagan valley. Occasionally, the authors' intimate knowledge of the Okanagan and its birdlife shine through with such animation that one is forced to take notice. Here is one example:

> "A vivid impression remains of an immature Goshawk plunging through the forsythia outside our living room window, straight into the middle of covey of California Quail. The Quail exploded in all directions, leaving the hawk in disarray, empty-taloned, and apparently outraged at its failure."

Buried in these accounts are some fascinating chronicles of species that have declined such as the Prairie and Peregrine Falcons, Swainson's Hawk, Sage Grouse, Yellow-headed Blackbird, and Black Tern. Or others that have only recently arrived to the Okanagan such as the White-throated Swift, Starling, Clay-coloured Sparrow, Bobolink, and House Finch. Many of these accounts contain some remarkable observations of bird behaviour. How about the Say's Phoebe nesting site which produced two broods every year between 1963 and 1972? Or the loon that took trout off a fisherman's line? Or a brood of Dark-eyed Juncos fed by a pair of Robins?

I have two comments about the species accounts. First, I would have liked some acknowledgement that Okanagan banding records had been examined. Perhaps there are simply not enough to shed new light on Okanagan bird movements and longevity. Second, I have some problems with the interpretation of the histogram data. For instance, only nesting and fledgling records were used as breeding records. As a result, it appears that records of singing males on territory are recorded in the non-breeding graph. This, I suspect, may give readers an inaccurate impression of the breeding presence for some species whose nests or young are difficult to locate, for example, Solitary Vireo or Western Tanager.

The photographs and illustrations are a major asset to the book. The fine line drawings were done by well known Okanagan artist Allan Brooks. The photographs are of good quality. Most are modern, showing the diverse landscape of the Okanagan. Also included are some fascinating old photographs of the original Okanagan which make for startling and disturbing comparisons with the present.

The Cannings are to be congratulated on the publishing of a very fine regional bird book. The two major objectives outlined in the book's preface are squarely addressed: spelling out the known biology of Okanagan birds and showing where the gaps lie. I strongly suspect the *Birds of the Okanagan Valley* will be a standard against which similar books across Canada will be measured.

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The Collins Field Guide to the Mammals of Africa including Madagascar

By Theodor Haltenorth and Helmut Diller. Translated from the German by Robert W. Hayman. 1988. (Reissue of 1980 edition). Stephen Greene Press. (Distributed by Penguin, New York). 400 pp., illus.

The Collins Field Guide to the National Parks of East Africa

By John G. Williams. 1988. (Reissue of 1981 edition). Stephen Greene Press. (Distributed by Penguin, New York). 336 pp., illus.

Although the *Mammals of Africa including Madagascar* field guide is large, containing 400 pages of small-print text, it is not a definitive work, omitting as it does almost all small species of rodents and insectivores, and all bats. For the hundreds of species it does describe, it usually gives details under the headings of Identification, Distribution, Habits, and Reproduction. There are small distribution maps, a few line drawings, and 63 attractive color plates of animals. A lengthy introductory section discusses the geological and climatological history of Africa, and how mammalian life evolved on this continent. Maps give the climatic zones, the vegetation zones, and the varying altitudes of the continental terrain.

Despite the impressive format, I was disappointed in the one page of information provided for one common species, the giraffe. The French spelling is incorrect (la giraffe instead of la girafe); the horn description is weird ("1 pair on forehead, 2 smaller on crown, sometimes a stud or small horn between both pairs"); the tongue is dark, not "flesh-coloured" (whatever that means); weight is given as 500-800 kg, yet individual males have weighed over 1200 kg; there is no "family troop" as such; the sentence "Dominant males with their wider view may add to their troop" is incomprehensible; to write "midday standing in shade," is misleading, because even if shade is available giraffes often stand or lie at midday in the sun; and to state that giraffes drink every two days or at least once a week is wrong. The distribution map indicates that giraffes are more widespread than they really are at present, perhaps because this work was first published in 1977.

The National Parks of East Africa supplies far less information on each species, but even that on the giraffe is incorrect. The text claims there are two species, the Reticulate Giraffe and the Common Giraffe, with the latter represented by two subspecies, the Masai and Rothschild's. In fact, all three types are subspecies of a single giraffe species. The text describes briefly only the appearance, distribution and habitat of each species in the 73-page Part 2, "The Mammals of East Africa." Despite this title, most bats, most insectivores, and most rodents are again omitted.

Part 3 (94 pages) of this guide is more correctly titled "The Commoner Birds of East Africa." There are about 1294 birds in this area, comprising Kenya, Uganda, and Tanzania, so only those most frequently encountered are discussed in groups or as individual species. As with the mammals, there are some line drawings and many beautiful colored plates. The art work is by Norman Arlott and Rena Fennessy.

Part 1 (150 pages) of this book, "The National Parks, Game Reserves, and other faunal areas," seems especially useful for anyone planning to visit Africa. Over eighty parks are described briefly, discussing how to reach them, their main physical attributes, and the animals one could hope to see there. For the better-known parks and reserves, long lists of resident mammals and birds are included. For these popular parks, 25 maps are given showing roads, tracks, rivers, lakes, and campsites.

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Waterfowl in Winter

Edited by Milton W. Weller. University of Minnesota Press, Minneapolis, Minnesota. 640 pp., illus. Cloth U.S. $71.95; paper U.S. $29.50.

The classical dichotomy among researchers is that some want to pursue a subject just to increase our basic knowledge, whereas others feel the work should be directed towards a tangible goal. The balanced response is that we need both approaches.

The classical aim of conservationists has been the preservation of a species breeding area. Great efforts have been expended to preserve or increase waterfowl "production" by conserving or expanding their breeding habitat. Less attention has been paid to the need and role of wintering areas.

In 1985, a group of the senior North America scientists involved in waterfowl research arranged a conference to highlight two key issues. First, the importance of the wintering grounds in the biology and hence the survival of ducks and geese. Second, to raise the profile of targeted research to meet the immediate needs of habitat managers.

Out of the over 100 papers given at the Conference the organizers chose 47 and compiled them into a volume called *Waterfowl in Winter*. In doing so they have begun to achieve their first objective. The profile of many vital scientific issues has been raised among concerned scientists. This will undoubtedly translate into an increased awareness among other researchers, conservationists, and concerned naturalists. I doubt if it will reach the general public or, more important, the decision making politicians. It is essential to develop the right message but it is also necessary to transmit that message to the right audience. The delegates missed an opportunity to develop a communications strategy.

I have considerable misgivings about the progress made towards their other objective. The majority of papers have a strong mind-set toward producing more publications or earning Ph.D's. Despite the logical call for more research aimed at supporting the habitat managers in their immediate problems, there is an undercurrent of emotional resistance away from the comfortable world of pure research. That does not mean the information contained in these selected papers is not useful. Both scientists and managers will find essential information invaluable in developing a better understanding, which, in the long-term, will enhance waterfowl's chance of survival.

Indeed, the papers represent the state-of-the-art background for North American waterfowl biology. Reproduction, social behavior, activity, budgets, feeding, ecology, physical condition, habitat issues and management, population, and disease are all covered. All papers have been peer reviewed by the leaders of waterfowl research. In addition a panel of experts gives a summary of the progress made at the symposium and recommends the direction for future research. The final result is a sound, broad spectrum scientific document that will be invaluable to all those involved in waterfowl management and research.

There were some international participants, but the bias is overwhelmingly North American. However, the issues raised and the fundamental science discussed can be transposed to most areas of the world. This book deserves, then, a wide distribution.

It only remains to urge the organizers to continue to hold such seminars at appropriate intervals. This will ensure a better degree of coordination on wildfowl research, and will continue to emphasize the importance of wintering areas in relation to breeding and migratory sites. I suggest they continue to divert some of the research energy into the more immediate problems faced by managers and that they develop a communication strategy to promote the wildfowl's and their needs with the decision makers.

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The Ancestral Kestrel

By David M. Bird and Reed Bowman. 1987. Raptor Research Foundation and Macdonald Raptor Research Centre of McGill University, Ste. Anne de Bellevue. (Distributed by St. Croix Nature Center, Hastings, Minnesota). vii + 178 pp., illus. U.S. $12.50 plus shipping.

This somewhat diverse assortment of papers about various kestrel species comprises the proceedings of a symposium held in St. Louis, Missouri in 1983. The collection begins with a paper on evolutionary aspects of systematics in the 15 or so (worldwide) species of "kestrels". This is followed by 11 papers concerning American Kestrels (*Falco sparverius*), two about the Eurasian Kestrel (*F. tinnunculus*), one about both of these species, and one paper about the Greater

Kestrel (*F. rupicoloides*) of South Africa. Four of the papers are reviews: one on hunting behavior, another on prey selection, a third concerning competition for nestboxes between kestrels and starlings, and a fourth on the use of kestrels in toxicology studies. Among the other subjects explored by participants at this symposium were foraging behavior, nesting success, winter habitat separation by sex, dispersal and inbreeding avoidance, and size and weight measurements of mated pairs.

Different readers of these proceedings will no doubt find different highlights among the papers, according to their particular interests. I found many gems of thought-provoking information among the various contributions, although at times the reading was somewhat heavy going. My own favorite in the collection was a paper entitled "The allocation of energy in the annual cycle of the kestrel,*Falco tinnunculus*", by Masman and Daan. Energy expenditure by kestrels during their various activities was measured by three different methods, including the use of doubly labelled water, and involving both field and laboratory situations. In their introduction Masman and Daan point out that the skeleton of theory in behavioral ecology "often outgrows the flesh of empirical data". This is unquestionably so, and it is good to see a study in which the empirical data consist of detailed and extensive observations, and which then follows with some theorizing about possible alternative strategies.

I had several minor criticisms of the book. The title does not describe the book's contents very well — only the first of the 16 papers deals with evolutionary matters. I suppose that the rhyming title was chosen to attract the interest of readers, but given the academic nature of the papers, it would perhaps have been better to simply entitle the book "Proceedings . . . etc." A list of the English and Latin names of all the kestrel species would have been helpful, perhaps in an appendix, as well as a good map of the world distributions of all the species. There are a number of typographical errors, and quite a list of errata, but these do not detract much from the major value of this publication: namely, to make available to a wider audience a group of papers that might otherwise be difficult to obtain. This is not an introduction to kestrels — rather, it is a reference source for persons already interested in this graceful little falcon.

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Birding in Atlantic Canada — Nova Scotia

By Roger Burrows. 1988. Jesperson Press, St. John's, Newfoundland. 163 pp., illus.

Roger Burrows has written a wonderful little book. It is exactly what I would have liked to buy when I moved to Nova Scotia some years ago. It describes, in detail, what birds can be found and where to find them.

Burrows has split the book into 20 sections which cover the most important birding zones in the province. This choice is excellent and I can't think of any nook of consequence that he has missed. (I did think of the mouth of the river Avon which, while significant to shorebirds, is very difficult to access.) Indeed, he often describes minor locations that are worth a quick side-trip whenever you are in the area.

All the sites are located on a provincial map at the beginning of the book. Then each site is covered by a larger scale, more detailed map at the start of the chapter. The text gives good directions to supplement the maps. These are often essential as many of the sideroads are obscure.

The author lists all the likely birds that can be found in the regions covered, and explains how they vary with the seasons. Each species name is printed in bold type, making it easy to pick out the species of interest. However, I found this portion of the book to be very optimistic. The visitors, and these are the type of people who will benefit most from this book, could get an inflated impression of their chances to see birds. For examples, under the write-up of Hartlen's Point, Burrows mentions Little Stint as a late fall migrant. This incredible rarity has occurred only once but receives a similar treatment to Baird's Sandpiper, a much more common bird.

Burrows would have been wiser to use typical, rather than maximum numbers for common birds. For Evangeline Beach he quotes counts of 45 000 sandpipers. This would make it the second most important shorebird site in Atlantic Canada (after Mary's Point in New Brunswick). This is not supported by the C.W.S. shorebird survey nor my own experience. Five to 10 000 would have been more reasonable and typical. Similarly, Burrows mentions many good locations from which to look for seabirds. He does not make it clear, however, that you have to be there at exactly the right date, wind condition, and tide to see anything of significance. Often too, these birds are far offshore.

Seeing the unmistakable silhouette of a Gannet may be good for a daily tick but is not satisfying enough for a life-bird. In general, Nova Scotia has less birds than the more-diversified Carolinian zone that covers much of eastern North American. The typical visitors will see fewer birds than they are used to, but many of them will be maritime specialities. In fact, Burrows could have borrowed one of Jim Lang's ideas and provided a list of Nova Scotia specialities referenced to the best locations.

Despite these criticisms, I thoroughly recommend this book to all potential visitors and newly-moved maritimers. It will aid immeasurably in planning and in finding target birds and visitors will be well pleased with their purchase, provided they tone down the optimism.

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BOTANY

Conifers

By Keith Rushforth. 1987. Facts On File Publications, New York. 232 pp., illus. U.S. $24.95, $33.95 in Canada.

If you have a horticultural bent then this book on conifers might interest you. It is a book written for the avid gardener. The author, Keith Rushforth, is a freelance arboricultural consultant and a former curator of an arboretum. He has a particular love for conifers and suggests that they are not properly appreciated. He defines conifers to include three orders of the Gymnospermae — the Ginkgoales, Coniferales and Taxales. Many of these are widely planted in Canada.

The author valiantly grapples with the concepts of genus, species, subspecies, varieties and cultivars before delving into the biology of conifers, their various uses in the garden, the many ways of propagating them, methods of planting and replanting and problems of pests and diseases. As for the last topic, it was gratifying to me that more emphasis was placed on clean gardening practices to control diseases rather than resorting immediately to the application of chemicals.

A gazetteer of conifers comprises the largest section of this book. Here are arranged detailed descriptions of the plants. This includes where they occur naturally, life zone hardiness, their growth characteristics, and hence their suitability for various places in the garden, as well as concise descriptions of leaves, reproductive structures, seeds, and fruits. Happily, one does not need to know the order or the family to which a genus or species belongs because all the genera are arranged alphabetically, and the index of English names will get one very quickly to the right page if the Latin name is not known. Within each genus the species, subspecies, varieties, and cultivars are similarly arranged alphabetically under their respective higher category. A perusal of this section shows the tremendous variety of conifers which are theoretically available to us and whets one's appetite to search out something different for that next planting.

It is the gazetteer section which should make *Conifers* a good reference book. However, the author is British, and although he includes hardiness zones and maps of North America, many of the species, varieties, and cultivars described will not be found for sale in our local nurseries. And the corollary is true, that other varieties and cultivars not mentioned in this book are available to us. This detracts somewhat from the usefulness of this book for Canadians.

Conifers is well-organized and enhanced with attractive and instructive black-and-white drawings. There are only eight coloured pages, and, considering the focus of this book is on cultivated plants, I thought that some of these pictures were not well chosen. There is a useful glossary, an index to the Latin names, as well as a separate index to English names, but no index to topics. I think that this is a drawback. It would be useful, for instance, to be able to look up quickly plants suitable for hedges or for rock gardens. Rushforth writes well and the general format of the book is very pleasing.

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Catalogue bibliographique des bryophytes du Québec et du Labrador

By Marc Favreau and Guy Brassard. 1988. Occasional Papers in Biology No. 12. Memorial University of Newfoundland, St. John's. 114 pp. $5.50.

This is an extremely useful catalogue of all the literature reports of bryophytes for Quebec and Labrador, Canada. The bryoflora of this eastern part of Canada, according to the authors, includes: 3 species of hornworts; 102 species, 5 subspecies, 13 varieties, and 2 forms of liverworts; and 599 species, 5 subspecies, 59 varieties, and 2 forms of mosses. The catalogue is a revision of Lepage's Catalogue published in 1944-1946 and it represents the first list of all the bryophytes reported for Labrador, updating the moss list published by Brassard and Weber in 1978 (Canadian Journal Botany 56: 441–466).

The Introduction to the catalogue is in both French and English. However, statements made elsewhere in the catalogue are in French only. The two areas covered by the catalogue are divided into a total of 28 regions. Quebec is divided into 23 coded regions, based mainly on lines of latitude and longitude, while Labrador is divided into five regions, employing the same coded regions used by Brassard and Weber (1978) in their moss checklist. The taxa of hornworts, liverworts, and mosses are listed separately in alphabetical order. Each taxon listed is followed by the code for the region it is reported from and the code numbers in parentheses behind indicate one or more of 350 bibliographic citations found in the list at the back of the catalogue. This method of reporting each taxon thereby pinpoints each record in a specific part of Quebec and Labrador and makes this work all the more useful.

The catalogue represents an enormous amount of work by the authors who have done an admirable job of compiling the literature reports of bryophytes for this huge area. It will make life a lot easier for bryologists in their floristic and taxonomic studies of the bryophytes of Quebec and Labrador.

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Plant Strategies and the Dynamics and Structure of Plant Communities

By David Tilman. 1988. Monographs in Population Biology; 26. Princeton University Press, Princeton. 360 pp. illus.

This exciting book presents an elegantly simple model of resource allocation in plants that explains much of the variation in plant life histories and plant morphologies within and between species. This variation allows the individuals with the best resource allocation pattern for a specific site to outcompete their neighbors. Therefore, this model provides a very useful explanation for the variability that is found in plant populations, within plant communities, between plant communities, and during primary and secondary successions. Tilman is the first to fully develop, explore, and test this model as exhaustively as he has done in this book. By doing so, he has refined several major plant ecology concepts. As a result, this book is of monumental significance to ecologists interested in the spatial and temporal pattern of plant species and plant communities.

His theoretical model is based on the simple dilemma that faces most terrestrial plants. Since they are dependent on both light (an aboveground resource), and soil nutrients (belowground resources), plants must allocate their available energy and nutrients to the growth of both aboveground and belowground structures. However, plants must optimize the proportion of their growth materials that are devoted to roots and to stems and leaves so that they can efficiently utilize their available resources before stronger competitors usurp those resources. Since access to aboveground and belowground resources varies widely from site to site due to wide variations in the abiotic and biotic environment, there is wide variation in optimal resource allocation patterns. Different optimal allocation patterns result in different plant morphologies. Different plant morphologies result in different potential growth rates due to differences in the proportion of resources devoted to above- and belowground structures. The optimal resource allocation ratio and its corresponding growth rate vary along gradients of soil nutrients, light availability, and disturbance rate.

Since the morphological and physiological plasticity of plants is limited within species but almost limitless among species, different species with their different resource allocation patterns and growth rates are optimal for different combinations of soil nutrients, light, and disturbance rate. This explains most of the variation in species composition within and between plant communities. Along a temporal scale, fast-growing pioneer and early seral plant species with low stem: high leaf: high root allocation ratios gradually increase the soil nutrient supply and reduce light availability. This favors the slower growing late successional and climax species which have a higher stem allocation ratio that enables them to be better competitors when light is the limiting resource during many late seral stages.

In one of the last chapters, Tilman compares his model's predictions to the results of his five-years of very thorough experimental work on plant dynamics and plant succession at the Cedar Creek Natural History Area in central Minnesota. The results of this work back up most of the model's predictions. Where the model fails, Tilman gives alternate explanations and lists several areas of investigation which could lead to improvements in his model. As Tilman points out in his conclusion, one single model may never be able to explain every aspect of succession and plant community dynamics without becoming too complicated to be useful. However, his model does make a giant step forward in providing simple explanations for plant strategies and the dynamics and structure of plant communities.

While Tilman's model obviously provides fertile ground for hypothesis generation in basic plant ecology, it will be of great value to applied ecology. It is easy to imagine aspects of this model being used to develop grazing strategies in range management that will accelerate succession on rangelands. It could also be used to refine forest regeneration strategies and to improve rehabilitation strategies for severely disturbed lands.

Most of the space in this book is devoted to the development of the concepts behind this model with the assistance of numerous graphs. The author makes excellent use of isoclines to illustrate his points. His explanations of these and other graphs are clear and easy to follow. The writing style is very clear and fast flowing. This is a very well written book. Its easy-to-read nature ought to make it very popular with researchers, graduate students and upper-level undergraduate students in botany and related applied sciences.

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Postglacial Vegetation of Canada

By J. C. Ritchie. 1987. Cambridge University Press, New York. 178 pp., illus. U.S. $70.

Professor Ritchie at the beginning of the Preface to this most thought-provoking book states: "The aim of the book is threefold: first, to assemble the published information on the history of the plant cover of Canada for the latest part of the Quaternary — during and following the most recent major ice age; second, to search for patterns of vegetation change and to evaluate such alternative explanations of these changes as climatic factors, varied rates of species spread from Pleistocene refugia, biological factors that might have controlled the spread and abundance of species, soil and geomorphological factors, chance events, and other influences; and third, to expose interesting, useful, and challenging problems in palaeoecology that might be solved by imaginatively designed searches for new data or novel analyses of the existing record."

To accomplish these aims Professor Ritchie has divided the book into eight sections dealing with the biogeographical setting including geology and bioclimates, autecology and pollen representation, glacial refugia, the fossil record, and a reconstruction based on that record of some major elements in the flora through to modern times.

This book will be required reading for any student with an interest in the postglacial history of Canada's vegetation. It contains a wealth of information, not only from the author's extensive field work but a condensation of the work of others who have studied in this field across northern North America. An extensive bibliography gives many opportunities for deeper study.

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Atlas of the Vascular Plants of Utah

By B. J. Albee, L. M. Shultz, and S. Goodrich. 1988. Occasional Publication No. 7. Utah Museum of Natural History, Salt Lake City. 685 pp., illus. U.S.$26.00 + U.S.$4.00 shipping.

The bulk of this work consists of a collection of 2438 maps depicting the distributions of the vascular plants of the State of Utah which at the time of completion were known from more than one area in the State. Each map is accompanied by an informative paragraph indicating the status of the plant — native or introduced, annual or perennial, herb, shrub or tree, common name, usual habitat, flowering time, and altitudinal range. These maps are arranged alphabetically by family and within the family alphabetically by genus and species.

An appendix contains an annotated list of 384 taxa that are known only from a single location or an area sufficiently small to have been represented by a single dot on a map. Entries on this list that have not previously been recorded as forming part of the flora of Utah, are followed by the acronym of the herbarium in which voucher specimens for those taxa are preserved. Species whose names are preceded by an asterisk are currently considered as threatened or endangered by the United States Fish and Wildlife Service.

A short introduction by James A. MacMahon describing the vegetation of Utah, a Foreword, a Preface, a Bibliography, and an Index complete the work. The latter includes both common and scientific names and selected synonymy. An interesting innovation is the use of contour maps rather than plain outline maps on which to plot distribution. A page-size contour map on which the various mountain ranges and plateaus are indicated together with a facing outline map depicting the counties at the beginning of the book provide readily used geographical information.

Although the botanical treatment is somewhat more conservative than the recently published *A Utah Flora* (1987), it is a welcome companion to that flora. It will serve as a basis for phytogeographical studies within the state of Utah and will certainly provide a challenge to botanically interested individuals to find new stations, particularly for those species of restricted range. It will also provide botanists in neighbouring regions a most useful tool for comparison of plant distributions as they undertake taxonomic and phytogeographical studies.

The *Atlas of the Vascular Plants of Utah* joins the mosaic of such atlases, some included in floras and others standing on their own, as *Atlas of the Flora of the Great Plains* (1977), *Flora of Alberta* (1983), *Vascular Plants of Continental Northwest Territories, Canada* (1979), *Flora of Alaska and neighboring Territories* (1969), and the series of provincial studies on rare and endangered species published by Canada's National Museum of Natural Sciences. Hopefully, this will encourage botanists in other parts of North America to help complete our knowledge of the flora of this continent by producing similar works for the areas with which they are familiar.

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Wildflowers of Churchill and the Hudson Bay Region

By Karen L. Johnson. Illustrated by Robert R. Taylor and Linda Fairfield. 1987. Manitoba Museum of Man and Nature. 400 pp., illus. $19.95.

Churchill, one of the few accessible meeting places of tundra, boreal and coastal ecosystems in Canada, has become a magnet for naturalists and biologists. Without walking far outside of town, a visitor can see large arctic mammals, northern birds, insects, and a wide diversity of spectacular wildflowers. Karen Johnson has addressed the need for a well-illustrated field guide to the more conspicuous native plants of the area. Approximately 160 species are treated fully, each having a page of descriptive text by the author, and an illustrative facing page consisting of a colour photograph (by Robert R. Taylor), or a water colour painting or black-and-white drawing (by Linda Fairfield).

According to the "Introduction", the book attempts to provide a non-technical guide to plants found around Churchill and York Factory as well as other parts of the Hudson and James Bay region. The book uses an identification key adopted from *Newcomb's Wildflower Guide*. This is based on a classification of plants into groups according to flower, leaf, and plant types. Plant descriptions are then arranged into groups according to the sequence in which they emerged from the key rather than the taxonomic sequence found in most texts.

Species descriptions are concise and interesting. Each is headed by a statement as to which of the plant groups the species belongs (from the key). Below this are given its common, scientific, and family names. The rest of the descriptive page provides sections entitled: "Other names", "Description", "Habitat", "Flowering" (i.e. dates), "Comments", "Range", and sometimes a "Note" which is usually used to distinguish the species from other similar ones not dealt with in the book. Dr. Johnson has written at a level that is likely to satisfy both the scientist and the casual naturalist.

Slightly more than half of the species are illustrated with colour photographs, and of the remainder — two-thirds are water colour paintings and the balance — the graminoids — are black-and-white drawings. The photographs are superb in detail, colour, artistic composition, and show the entire plant growing in its natural habitat. A personal favorite is the photograph of *Moneses uniflora*. The inverted flower has a mosquito resting on it and on its head one can clearly make out a large pollinium of an orchid. The water colour paintings excel for the same reasons as the photographs, both show sufficient detail that they alone may be used for identification purposes. Most portraits are artistically complemented with a line sketch of substrate, landscape or surrounding plants.

The first fifty pages are divided into a number of short sections. Diane Erickson, "a grateful Churchillian", has written a short and encouraging foreword. Following this is a section on the natural and human history of the area which includes a description of each major plant community and ends with a double page diagram showing how the communities are related to land forms. The five pages of human history are interesting, but I am not sure how they relate to a wild flower study. A short botanical section follows, which arms the reader with sufficient floristic understanding and terminology to be able to tackle the identification keys which follow. The back of the book has a brief reference section and an updated species list of native and introduced species. The list is co-authored with Dr. David White from the National Museum of Natural Sciences.

I have only one quarrel with *The Wildflowers of Churchill and the Hudson Bay Region* and that is its title. One question is — what is a wildflower? The book includes all kinds of vascular plants from horsetails to aspens and white spruce. We are also not sure how to interpret the extent of the "Hudson Bay Region". These are perhaps picky details — for consideration in the second edition!

This latest publication from the Manitoba Museum of Man and Nature matches the level of excellence achieved in other recent publications. Karen Johnson, Robert Taylor, and Linda Fairfield are to be congratulated for providing northern residents, naturalists, and biologists with an attractive identification guide at a very reasonable price.

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Plantwatching: How Plants Remember, Tell Time, Form Relationships, and More

By Malcolm Wilkins. 1988. Facts on File, New York. 207 pp., illus. U.S.$29.95; $39.95 in Canada.

This is a superbly illustrated book. The photographs are outstanding. The text, unfortunately, is much less satisfactory.

There is no preface, and the author nowhere explains what kind of readers he had in mind for his book, which sets out to "describe and explain how plants live, work and behave." Presumably it is not aimed at naturalists since it dismisses some topics as belonging to "the province of ecology, . . . mentioned here for the sake of completeness." It may be intended for the educated layman in search of an authoritative exposition of what modern botany is all about, and some parts of the book do fulfil this goal. But it is doubtful whether anyone in this category really wants to read, for instance, that "the CO_2 released [during photosynthesis] in the bundle sheath cells is, however, fed straight into the Calvin cycle where it combines with ribulose biphosphate to form two molecules of the three-carbon phospho-glyceric acid, just as it does in C-3 plants."

This sentence is representative of a large fraction of the book, which is really a watered-down textbook. The profusion of exclamation marks at the end of declarative sentences, presumably to show that they are interesting, does not turn a textbook into a popular book; it is merely ungrammatical and irritating. I would not describe the material as over the heads of educated laymen (who are at least as intelligent as professional scientists), but as unlikely to interest them; nobody enjoys learning things by rote.

In spite of the author's impressive qualifications, the book contains many misleading statements. Examples: He repeatedly writes of grasses and cereals as though cereals were not grasses. He describes a fern antheridium as a large [*sic*] spherical structure and a moss capsule as a large [*sic*] hollow structure; large relative to what? He implies that a high-powered microscope is required to see that the sporangia of *Lycopodium* are all alike; a hand lens is sufficient. Conifers are described as monoecious (but what about junipers and yews?) and as able to photosynthesize all year long (in arctic winter temperatures?) Oil as well as coal is said to be the fossilized remains of ancient pteridophytes; it is generally thought to come from marine microfossils. The cotyledons of all germinating dicots are said to become "hugely swollen as in peas and beans."; how about lettuces and carrots? And what would a zoologist make of the statement that a "unique [*sic*] feature of plant cells is that each one contains the genetic code for the whole plant"? An error that may be only a slip is the statement that 1 Megapascal = 10 bars = 0.98 atmospheres; in fact, 1 Mpa = 9.8 atm.

The greatest lost opportunity was that of explaining to the uninitiated that a pollen grain is not equivalent to a sperm as so many non-botanists, even naturalists, mistakenly believe. The life cycles of cryptogams are described, and the part played in them by free-swimming sperms. The phanerogam lifecycle, however, doesn't even have a paragraph to itself but just one sentence, which states that "In the more advanced plants like the conifers, and ultimately in the flowering plants, the sporophyte is the dominant generation and the gametophyte is much reduced in size, dramatically so in the case of flowering plants where the male gametophyte consists of just one or two cells within the pollen grain". Is the reduction less dramatic in the conifers? And where do the sperms come from? Not until two chapters later do we find out.

It is a great pity that so much potentially interesting material is so badly presented, especially when the illustrations are outstanding.

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ENVIRONMENT

Guardian of the Wild: The Story of the National Wildlife Federation 1936-1986

By Thomas B. Allen. 1987. Indiana University Press, Bloomingdale. viii + 212 pp., illus. U.S. $18.95.

Who speaks for Earth? Carl Sagan's question was a good one. This book partly answers it, for in half of North America the strongest voice on behalf of Earth seems to be that of the National Wildlife Federation.

Here is a readable history presented with impressive candor, starting with the ideas of "Ding" Darling who successfully championed national conservation action in a number of viable organizations in the 1930s, and ending with Ronald Reagan's man in the Bureau of Land Management, James Watt, whose ideas on parks, wildlife reserves, wetlands, and other such priceless bits of Earth were a century out of date.

After a shaky start lasting many years in which lack of money constantly threatened survival, this American federation grew to have three million members, four full-colour magazines, and access to most of the nation's schools in an educational program which begins with pre-school children. It lobbies with success for sound conservation laws; it often has direct access to the nation's President; and with high frequency it sues corporations and government departments over projects destroying wildlife habitats. Fortunately for the budget, most of these confrontations are settled before reaching the courts, but a small percentage does involve the federation's dozen or so lawyers in lengthy court battles. Illegal projects are reported to this federation's head office in Washington through a nation-wide network of observers. Recently, regional offices have begun to locate legal help closer to the lands requiring legal confrontations.

Although I have known about this federation for decades, I was out of date in my views of it. Its scope and its many successes, even its guiding principles, were stunning surprises when revealed by this book. In fact its pages were peppered with unexpected revelations, large and small. This is a powerful and active U.S. federation with wide-ranging experience in education, legislation, and litigation.

Perhaps this organization's greatest accomplishment is the impressive diversity of interests of its members. As in so many past conservation successes, this one began in hunters' clubs. Almost from the beginning, however, other kinds of clubs were members of the federation, ranging from garden clubs to organizations of hikers, naturalists, and other wild land savers. It was not easy to keep this mix together on all issues addressed by the federation, but through fifty years only the anti-hunters and anti-trappers seem to have been unable to join what must be the world's most successful citizen's crusade to prevent the unnecessary destruction of land, water, and the wild lives needing these for habitat. As stated by a Vice-President of the Federation: "Whether you are a hunter or a bird photographer, you have basically the same environmental interests".

There is much practical information in this book to take in and think about. It is a field-tested blueprint, U.S. style, for conservation action which puts effort where it will do the most good.

This history might be summed up as a success story about taking a motherhood cause to a nation with hard work and determination, first building a large membership to have monetary and political clout, then learning how to help people help themselves through education, politics, and the law.

This is not just a good read, but a reference book as well, useful no matter where you live.

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Models of Nature: Ecology, Conservation, and Cultural Revolution in Soviet Russia

By Douglas R. Wiener. 1988. Indiana University Press, Bloomington. xii + 312 pp., illus. U.S. $35.

Models of Nature is a detailed history of changing views of nature, ecology, and conservation in the Soviet Union. As such, it should interest North American ecologists and conservationists. While the names, political events, and interest groups were different in Canada and the United States from those of Tsarist Russia and the young Soviet Union, the reader gets a sense of déjà vue concerning conservation problems and suggested remedies.

The author discusses pre-revolutionary trends in conservation, changing attitudes under the new political regime, and the detrimental effects of the New Economic Policy on wildlife and habitats. Economic recovery resulted in "an increased capacity to despoil nature and to wear down stocks of renewable resources." Concerned individuals and organizations were pitted against the government's larger interest and often misguided efforts to provide food for the population by destroying valuable tracts of unique habitats.

Equally important are the chapters devoted to discussions of ecology and biology. Russian ecologists were in the forefront of studies in community ecology, and by the 1920s "gained a new appreciation of the role of the fauna in shaping historical development of natural communities." The term *biocenosis*, coined about this time, is roughly equivalent to Tansley's *ecosystem*! By the mid-1920s, ecology became an academic discipline in the Soviet Union, and courses were given at various universities. The subsequent need for "suitable field conditions" for ecological research led to increased demands for *zapovedniki*, that is permanent, protected territories for baseline investigations. In the early 1930s, theoretical ecology advanced rapidly. Soviet ecologists pioneered the study of trophic dynamics and quantification and Gauze "designed elegant laboratory experiments to illustrate the effects of density, refuge and predation in simple biocenotic systems." But during the First Five-Year Plan, politicians and the people became obsessed with the possibility of transforming nature; now ecological reserves and endangered animals, indeed "every molecule of nature," was seen as raw material for a Soviet agriculture and industry. The new trend, regrettably, led to the extinction of "ecological conservation."

The author also discusses, albeit too briefly, the development of a Marxist biology and its detrimental effects on natural science education and conservation. We get a new insight into the events leading to, and personalities involved in, the development of a distinctly Soviet brand of Lamarckism, Michurinism, which eventually became the "only acceptable explanation for evolutionary change."

Although this volume is full of information, it is quite readable, because of Wiener's lively style. The author must be commended for his deliberate attempt to reduce the usual western confusion concerning Russian terminology, by interchanging Russian terms with their English equivalent. I also much appreciated his use of non-sexist language and awareness of gender issues.

Models of Nature is a well-researched book, that deals with topics of great interest to Canadian naturalists, conservationists, and historians of science. Two appendices include information on the protected areas; a glossary, and lists of acronyms and abbreviations, and thirty-five black-and-white illustrations further enhance its usefulness. My only objection concerns the "index" — which contains no entries for the plants and animals discussed.

I highly recommend this book for individuals interested in ecology, conservation issues and the role of government in shaping our environment. It is a useful companion volume to Janet Foster's *Working for Wildlife*, and Donald Worster's *Nature's Economy*. It will be a challenge to write its North American equivalent! Any takers?

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MISCELLANEOUS

Aldo Leopold

By Curt Meine. 1988. University of Wisconsin Press, Madison. xvi + 628 pp., illus. Cloth U.S. $29.50.

In the long run it will be conservationists, over politicians or generals, to whom future generations will be most indebted. Among the major Americans in this field, Aldo Leopold ranks beside Henry David Thoreau, John Muir, Rachel Carson, and Tom Lovejoy. Leopold's life spanned the interval from a century ago, when the closing of the frontier raised the issues of how to manage the large but finite countryside, to post-World War II when the economic surge made these issues all the more acute. Leopold proceeded successively from Midwest to East to Southwest to Wisconsin, and Meine organizes this biography around these changes in venue. From a comfortable family background in Missouri, including early rambles, birding, and hunting, Leopold attended Yale and its Forest School. Overcoming the usual turmoil of emerging adulthood, he entered the Forest Service established by Teddy Roosevelt and served in Apache and Carson National Forests, becoming in due course Supervisor and Chief of Operations. During this period in which he struggled with the paradoxical mandate of protection and development, Leopold began to formulate his views on habitat conservation and game management. Of particular interest is the change in his attitude on the importance of predators over the years under the impact of events such as the population dynamics of the Kaibab deer.

With his move to Wisconsin, Leopold became increasingly involved in policies and controversies relating to game management and conservation. In all of his professional efforts he brought to bear wide knowledge and sharp self-criticism. Throughout, his family life, both at home in Madison and at "the shack" on weekends, provided a supportive framework. Leopold toured the forests of central Europe, defended the importance of wilderness, and articulated a general land ethic. Recognition for his contributions continued until the end of his life with a series of medals, citations, and awards. Before the publication of *A Sand County Almanac* for which he is now best known, Leopold died while fighting a grass fire at the shack, a fitting end to such an outstanding crusader for conservation.

Leopold's life was an ebullient mixture of natural history, hunting, science, family commitment, teaching, and politics. This fat biography provides a detailed and candid portrait of his professional and personal activities. The style is polished and perceptive, the text is accompanied by appropriate photographs, and lengthy quotations from his prolific writings and letters provide a personal flavour. Beyond his formal career and accomplishments, Leopold's pantheistic joys and sorrows, in his interactions with the natural world, which served as wellsprings for his efforts, are well documented. For all those interested in this major conservationist, or seeking inspiration or re-assurance in the continuation of the battles which he fought, this book affords valuable reading.

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Statistical Methods for Environmental Pollution Monitoring

By Richard O. Gilbert. 1987. Van Nostrand Reinhold (Canadian distributor, Gage, Agincourt, Ontario). x + 320 pp. $58.

This book is written specifically for environmental scientists engaged in pollution monitoring, and for students specializing in this subject area. An introductory knowledge of statistics is assumed. The book fills a great need by focussing on methods that are particularly well suited to pollution monitoring, and on problems commonly encountered in this field but seldom discussed in other texts.

Almost half of the book is devoted to sampling design, an all-too-often neglected step in pollution monitoring studies. Simple random, stratified random, two-stage, three-stage, systematic, and double sampling designs are discussed. The discussion includes advantages and disadvantages of each design under different environmental conditions, and criteria for selecting the best design. Methods of optimizing sampling effort (number and distribution of measurements) are given for each design, with prespecified constraints on available budget and precision to be achieved. The effects of temporally and spatially correlated data on mean and variance estimation, and on sampling design, are illustrated.

While there are other texts on sampling which cover much of the same ground (e.g. Cochran's, 1977, *Sampling Techniques*) few are as readable as Gilbert's book is to the non-statistician. The practical examples given are immediately familiar to readers with experience in pollution monitoring.

The chapter on grid sampling to locate "hot spots" of pollution will be of particular interest in the context of hazardous waste site assessment. It is shown how grid points can be spaced to achieve a prescribed limit on probability of missing the hot spot if it is there, and how Bayesian methods permit prior information to be utilized in defining the probability that a hot spot exists when none are found.

Methods are given for estimating quantiles, proportions, and means of pollutant concentration over a defined temporal or spatial domain, and for computing confidence limits on these estimates when data are either independent or correlated in time and/or space. Particular attention is given to lognormal, Weibull, gamma, and beta distributions, which are often used to describe pollutant concentrations, and to testing the fit of these distributions. Non-parametric methods are also described.

A number of methods are given for handling "censored" data sets, which often occur in pollution monitoring due to the detection limits of analytical instruments, and method performance is compared. Outlier detection methods are also described. These aspects of data handling are seldom discussed in general texts.

Simple and robust methods of temporal trend detection and description are given, along with methods for comparing trends among stations or regions. These methods are less labour intensive and have less stringent data requirements than Box-Jenkins time series methods. A computer program for trend testing is provided in the appendix.

Spatial trend description receives less attention, although response surface and moving average ("kriging") methods are briefly mentioned. The reader is referred to a comprehensive list of references for information on application of these techniques.

Statistical tables in the appendix provide critical values for the test statistics described. Included here are many tables not usually found in more general textbooks. Environmental scientists involved in any aspect of pollution monitoring will find this book a valuable reference.

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The Lobster Gangs of Maine

By James M. Acheson. 1988. University Press of New England, Hanover. 181 pp., illus. Cloth U.S. $20.00; paper U.S. $9.95.

The Lobster Gangs of Maine is based on data collected by the author and others for a variety of anthropological studies. The data were collected in the early 1970s to the mid 1980s. The geographical area covered by the studies is the Gulf of Maine.

Dr. Acheson provides a detailed look of the hierarchical structure of the lobster fishermen's society. This detailed look includes the interactions, position determination, and fishing territory protection of individuals and of harbor gangs.

The skills acquired and utilized by lobster fishermen are examined. This examination includes comparisons with available biological data for lobsters. An interesting result of the comparison is that a fair amount of what the fishermen believe about lobsters can and has been verified by scientific research.

The Lobster Gangs of Maine was listed as a controversial book by the publishers. The controversy arises from the concept of lobster fishermen being self-reliant individuals fighting the elements to obtain a living. The author provides a picture which is almost the complete opposite. He describes an individual surviving with the help of the community and the local harbor gang. The help being supplied by restriction of entrance to the profession and fishing area, information sources, and lobster dealer incentives.

Another point of possible controversy is the conclusion the author draws in regards to conservation of the lobster resource. In the final chapter Dr. Acheson concludes that the societal structure present in Maine at this time is a means of conserving the resource while utilizing the same. This conclusion would appear to be at odds with Hardins "tragedy of the commons" hypothesis.

The book has a short glossary of terms, detailed notes at the end of the book as well as a subject index. These added features I found were quite helpful.

I feel Dr. Acheson has provided a clearly-written detailed description of the lobstermen of the Gulf of Maine. An account that should be read by anyone interested in lifestyles to be found on the Eastern Maritime Coast.

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Catalogue of Columns, "Nature's Diary" by Alfred Brooker Klugh, in the Farmer's Advocate, 1912-1925

By W. W. Judd. 1986. Phelps Publishing, London, Ontario. 44 pp. $5.00.

This is a catalogue of titles and references of the nearly 600 columns by Alfred Klugh published in the Farmer's Advocate from 1912-1925. A brief biography of Dr. Klugh is also included. Alfred Brooker Klugh (1882-1932) was a naturalist with very broad interests and training, and was a founding member of the Wellington Field Naturalists' Club (Guelph, 1900), Queen's University Naturalists Club (1906), and the Great Lakes Ornithological Club (Point Pelee). He spent most of his adult life as an Associate Professor at Queen's University, Kingston, Ontario.

The weekly columns he wrote for the Farmer's Advocate were in addition to numerous scientific articles in journals (including *The Canadian Field-Naturalist*). While columns concentrate on single species of plants and animals, others have a country-wide scope, for example, meteorology, conservation, ethology, and biological control of pests.

This catalogue will be invaluable for anyone seeking natural history records of the early 1900s in Canada.

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Student Research in Canada's North

By W. Peter Adams and Peter G. Johnson. 1988. Proceedings of the National Student Conference on Northern Studies, November 18-19, 1986. Association of Canadian Universities for Northern Studies, Ottawa. 596 pp., illus. English and French. $25 in Canada; $35 elsewhere.

This volume contains the 99 papers presented by students at the National Student Conference on Northern Studies, November 1986. The papers are divided roughly equally among the life, physical, and human sciences. The distribution across the north and among the parent universities is remarkably uniform.

In clarity of organization and editorial quality, this volume is outstanding, and the editors and their supporting cast are to be congratulated on a superb achievement. Obviously, this review cannot begin to examine the contents in detail. All with an interest, scientific or more general, in the north will find much value in this compilation. Most of all, it sets out the exciting reality that a cohort of talented young investigators is in place to ensure that Canada's magnificant northland will be understood and examined in greater detail and with more up-to-date methods than ever before.

The National Student Conference has become a regular event, sponsored and organized by the Association of Canadian Universities for Northern Studies. It will achieve infinitely more than the endless commissions and ponderous deliberations of task forces that governments are prone to create when they are at a loss to know how to deal with a problem.

After three decades of work in the Arctic, I find the publication of this volume one of the most encouraging and important events I have observed. All readers of this journal will wish to have a copy.

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Systematics in Agriculture Canada at Ottawa 1886-1986

By William J. Cody, Douglas B. O. Savile, and Michael J. Sarazin. 1986. Historical Series No. 28, Minister of Supply and Services Canada, Ottawa. 81 pp., illus. English and French. Free.

In 1986, the Agriculture Canada Research Branch celebrated its one hundredth birthday. To help commemorate the occasion, several historical works were published. *Systematics in Agriculture Canada* is one of these works.

Systematics in Agriculture Canada described the founding and development of today's Biosystematics Research Centre in Ottawa. This is done on a department by department basis.

On the whole, the facts are presented in a concise and interesting manner, with a few interesting tidbits about each scientist who has contributed to the making of the Biosystematics Research Centre. The only difficulty I had with the text was keeping straight the time period each scientist was present.

I feel the book provides a concise, quick to read, historical look at one of Canada's research institutes of international reputation.

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Speak to the Earth: Wanderings and Reflections Among Elephants

By Vivienne de Watteville. 1935. (Reprinted 1988). Penguin, New York. xxxv + 329 pp. U.S. $7.95.

Vivienne de Watteville was a 28 year old English woman in 1928 when she undertook the year's journey in Kenya described in this autobiographical book.

It was her second trip to Africa. On the first she had accompanied her father as he tried to shoot specimens of all the larger mammals for a Swiss museum. She eventually presided over his deathbed at a remote camp after he was mauled by a lion. Despite this grim introduction to the continent (described in an earlier book, *Out in the Blue*), she was determined to return a few years later. As she explains, in a passage that will ring true for anyone who has been there, ". . . like all the others, I was drawn back again as irresistibly as a needle to the magnet . . . in spite of everything, Africa is one of the strongest bonds in the world".

Two things distinguished her second trip. First, she went, not to shoot, but to photograph and "make friends with the animals". Second, she went "all alone", using that peculiar colonial arithmetic that discounts the various "boys" (rarely more than a few metres away) who carried her bookcase, gramophone, and bathtub, who collected her food and prepared her meals, and who generally kept her alive in the wild.

My first impression was to be appalled, once again, by the intolerable arrogance of the Europeans in Africa, whether demonstrated in the author's attempt to "improve" Mount Kenya by planting watercress in an alpine stream, or in her atrocious sentiments on the African people (her "boys" are variously compared to small children and good dogs). Reading between the lines, though, and in comparison with the streak of crudeness and brutality evident in so many of her compatriots in Africa at that time, it is easy to see the author as a good, even enlightened person, constrained by the conventions of a late imperial mentality. If she were with us today, she would probably be a staunch feminist and environmentalist, much concerned with the inequities of the world.

The bulk of the book is a perceptive set of anecdotes and observations about the plains and mountains of Kenya, and their wild plants and animals, at a time when people were uncommon and rhino were abundant. The author never did "make friends with the animals", at least not to her own satisfaction, but she did manage to have a closer and more prolonged approach to that ideal than most of us are likely to manage. Her tales are likely to appeal to most naturalists, as long as they are able to turn a blind eye to the sociological irritants.

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Wilderness Survival Guide

By Monty Alford. 1987. Alaska Northwest, Edmunds, Washington. 103 pp., illus. $12.65.

Canada's weather can be quite extreme not only in the squeaky snows of the far north but also in the "banana" belt edging the Great Lakes. Indeed, I know people who where stranded a few hundred yards from Highway 401 in southern Ontario and had a miserable time reaching safety. Surprisingly little attention is paid to survival safety and each year we lose a few hunters, fisherman, campers, and children. Monty Alford has produced a book that could help reduce the potential for trouble. Perhaps we should make it mandatory reading for grade 12 students.

It is actually a combination book. Wilderness survival is written for those who backpack into difficult terrain or conditions. It is also written for those who inadvertently find themselves in trouble. The author devotes a large portion of the book to problems with winter in the far north but the lessons are valid for all of Canada. Wilderness survival in summer is so much easier, that I think this is appropriate.

The author has written nine short, terse, pointed, and readable chapters. These explain the basics of travel, from trip planning to water, ice, snow, and glacier travel. This is followed by the basic fundamentals of survival and food and cooking. The balance of the book covers signals and a miscellany of tips on ropes, medical kits, aircraft and so on.

Buried within these pages is information on sleds, snowshoes, stoves, snow shelters, ice chisels, and other valuable information. I was intrigued by an easily constructed stove made from a tuna, an apple juice, and a vegetable can. The section on food will change your ideas on how to choose supplies for a trip (and a few recipes that will make them useful and tasty).

I was curious about two points. The author did not mention cattails as food. This plant may not be available all over Canada, but where it is, it is the easiest to harvest and eat. He also did not make much reference to garbage bags, especially the bright yellow kind. These light, waterproof, and very visible plastic sacks have a multitude of uses.

I thoroughly recommend this small (13.5 cm by 21 cm, 170 g) book to all who might travel in the wilderness, and suggest it to all who travel. While I was reading it, three local people got into serious trouble outdoors within a few miles of our nation's capital. My copy is going in my emergency pack in the car trunk. It will add to the candles, matches, clothes, yellow garbage bags, and other emergency equipment. These will soon be joined by a tin-can stove. In Canada you never know when you'll need, both the equipment and the knowledge.

ROY JOHN

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Bill and Bev Beatty's Wild Plant Cookbook

By Bill and Bev Beatty. 1987. Naturegraph, Happy Camp, California. 174 pp., illus. U.S. $7.95.

This book is a collection of thirty edible wild food plants or groups of plants chosen for their availability, nutritional value, and because most are easy to identify. Chapters begin with a drawing of the plant or plants to be discussed, the scientific and popular names, and a distribution map. The introduction describes the plants and their habitat, the stage of growth at which they can be used, and may include information of historical or medicinal interest, or anecdotes related to collection and preparation of the plants. The two to ten recipes in each chapter are simple and easy to follow, often adapted from recipes for similar cultivated plants such as by substitution of milkweed shoots for asparagus.

The authors both have a degree in biology. They live and work in West Virginia. Bev is also an artist and responsible for the attractive and helpful plant sketches. Some of the plants or close relatives are continental in distribution, as indicated by the maps, but the book was obviously prepared for wild food enthusiasts in eastern North America. In Canada a few species, such as pawpaw, grow only in the Carolinian zone of southernmost Ontario. For the size of the book, there are an unusual number of appendices. They include additional recipes, a preface, a final word, acknowledgements, literature cited, a bibliography plus a list of contents, recipe index, and a much appreciated general index with both technical and popular plant names. There are also eight pages on wild plant nutrition with emphasis on certain minerals and vitamins. I found the literature citations to be confusing and regretted the omission of two excellent references, i.e. *Edible Wild Plants of Eastern North America* by Fernald, Kinsey, and Rollins (two of whom are distinguished plant taxonomists) and Kingsbury's *Poisonous Plants of the United States and Canada.*

The Beatty's have some interesting suggestions such as black cherry jello with wild violets pressed into the surface and a mosquito repellant to be used when picking raspberries that involves an Avon product. There is no need to eat day-lily buds (*Hemorcallis*); enjoy the flowers until they die then use them in soup or as a crisp nibble. While the plants described have been safely eaten by the authors there is always concern about untrained people and the many look-alike plants, some of which are toxic. Jewelweed in small amounts is not likely to cause harm, but the literature suggests that large amounts may. Cat-tail roots and other plants growing beside busy highways should not be eaten because of lead and other pollutants in the soil, and that applies also to plants growing in polluted waters. There should be a warning in the book against raw milkweed, especially for potential users in the dry midwest where many narrow-leaved species are known to kill animals when ingested (Kingsbury).

This pocketbook is attractively prepared, the contents are interesting but limited to a small number of plants. High marks go to the sketches, the maps, and the use of Latin as well as popular names. The small size will fit many pockets although covers may not stand much travel. However the ISBN number suggests that a hard cover is available. The book will be of most use to naturalists newly introduced to wild foods, and to those who collect books on the subject.

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YOUNG NATURALISTS

Animal Vision

By Terry Seddon. 1988. Facts on File, New York. 62 pp, illus. U.S. $13.95.

Vision is our principal sensory modality, and a book on animal vision can make much of this fact, as this one does very successfully. With a straightforward text and copious colourful illustrations and photographs, it presents visual examples of many species in many habitats (including the "monstrous eyes" of cephalopods).

Among the topics delineated are the physical aspects of light (including ultraviolet and infrared radiation), the role of the environment (e.g. aquatic refraction and spectral filtering), morphological features (e.g. retinal structure, ocular oil drops, and eye spots), physiological processes (e.g. focusing and inversion of images), and the role of behaviour (e.g. predatory motion and visual illusions). The book also includes a quiz, glossary, and index. The impressions of views through compound eyes and with UV vision are effective, and the human model with scaled-up eyes of a dragonfly effectively, if somewhat misleadingly, conveys the importance of vision in these insects.

With such material and its enthusiastic "Gee whiz!" style, Seddon's book, like Bailey's companion volume on mimicry and camouflage (also reviewed in this issue of this journal) provides an enjoyable introduction to animal vision.

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Mimicry and Camouflage

By Jill Bailey. 1988. Facts on File, New York. 62 pp., illus. U.S. $13.95.

Along with perenially popular dinosaurs and sharks, the phenomena of mimicry and camouflage provide rich material to provoke the interests of children in biology. This volume effectively explores this material, offering an abundance of examples from a wide variety of organisms of all sizes, habitats, and life styles.

Sensory aspects (especially vision), body pigmentation, countershading, disruptive colouration, and the correlation of anatomy and behaviour are all well described. The straightforward text is colourfully illustrated, and there are a brief index, bibliography, and glossary.

Two obvious omissions are a historical perspective and an explicit presentation of the selectionist interpretation of mimicry. It would have been easy to include portraits of Darwin, Bates, and Muller, and statements of their contributions. As presented, the account is entirely phenomenological and could serve as a Bridgewater treatise. Notwithstanding this, the book is an excellent introduction to the area.

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NEW TITLES

Zoology

Animal navigation. 1989. By Talbot H. Waterman. Scientific American Library. Freeman (distributed by Oxford University Press, Toronto). 256 pp., illus. $49.95.

The animal trail: four seasons of wildlife photography. 1988. By Manabu Miyazaki. Chronicle Books, San Francisco. 82 pp., illus. U.S.$12.95.

*__Atlantic fishes of Canada.__ 1988. By W. B. Scott and M. G. Scott. University of Toronto Press, Toronto. xxx + 731 pp., illus. $45.

Atlas ichthyologique des Indes Orientales Neerlandaises, volume ix. 1989. By Pieter Bleeker. Reprint. Smithsonian Institute Press, Washington. U.S.$50.

*__Atlas of wintering North American birds: an analysis of Christmas bird count data.__ 1989. By Terry Root. University of Chicago Press, Chicago. xxiv + 312 pp., illus. + overlays. Cloth U.S.$60; paper U.S.$35.

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Cover: Cover: A hybrid toad, *Bufo a. americanus* x *B. woodhousii fowleri*; calling male, Long Point, Ontario, 5 May 1981 [Canadian Museum of Nature (NMC) 21963]. Photograph courtesy of David M. Green (see article on the status of Fowler's Toad in Canada, pages 486-496).

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Community Patterns and Environmental Gradients of Buttonbush, *Cephalanthus occidentalis*, Ponds in Lowland Forests of Southern Ontario

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Faber-Langendoen, Don, and Paul F. Maycock. 1989. Community patterns and environmental gradients of Buttonbush, *Cephalanthus occidentalis*, ponds in lowland forests of southern Ontario. Canadian Field-Naturalist 103(4): 479–485.

Ten Buttonbush (*Cephalanthus occidentalis*) ponds in two lowland forests of southern Ontario were sampled for plant composition and environmental factors. Species presence was recorded in four zones: forest, mound, platform, and emergent. Water fluctuations were measured for 2 years. Species distributions across zones within sites (coarse-scale gradient) were limited by steep environmental gradients related to permanent inundation and presence or absence of flooding between the pond and forest floor. *Cephalanthus occidentalis, Fraxinus pensylvanica, Ulmus americana* and *Acer saccharinum* were the only woody taxa more common in the platform than in the forest zone. *Cephalanthus* was restricted primarily to the platform and emergent zones. Species richness declined from forest to emergent zone. Species distributions between ponds for the platform zone only (fine-scale gradient) were analyzed by detrended correspodence analysis. The primary compositional gradient was correlated with variation in water fluctuations, pond size, and soil moisture. Abundance patterns for *Cephalanthus*, however, were influenced by another factor: water depth. These analyses suggest how two scales of environmental gradients influence species distributions within Buttonbush ponds; the zonal coarse-scale gradient caused by flooded/not flooded conditions, and the fine-scale continuous gradient caused by variations between ponds in water fluctuation within a zone.

Key Words: Buttonbush, *Cephalanthus occidentalis*, community patterns, environmental gradients, lowland forests, Ontario.

Ecologists often analyze the changes in distribution and abundance of species populations using recognized environmental gradients (Whittaker 1975). Where gradients are steep, distinct zones of vegetation can often be recognized from site to site (Mitsch and Gosselink 1986). These zones can form the basis for an initial understanding of species responses to abiotic factors. Nevertheless, the same zone may vary slightly in its characteristics from site to site, and these fine-scale differences may also lead to changes in species composition. While such fine scale gradients may be expected, they are not always assessed.

Ponds dominated by *Cephalanthus occidentalis* (Buttonbush) are of interest because they contain both scales of gradients. Within a site, the pond environment changes rapidly from emergent zone to the unflooded surrounding lowland forest. The ponds, however, also vary continuously in the degree of water fluctuation during the season. Few studies on inundated lowland forests have emphasized the species responses to both coarse and fine-scale gradients, though several studies have done limited comparisons between sites (Conner et al. 1981; Robertson et al. 1984; Hupp 1986; Mitsch and Gosselink 1986). We have not found any published gradient studies for Buttonbush ponds, even though this is a common shrub-swamp community type in the Midwest of the United States (Nelson 1985).

In this study we (1) examine 10 Buttonbush ponds for the within-site changes in species distributions from emergent zone to adjacent forest edge (coarse-scale gradient), (2) examine compositional trends between sites for one zone (platform) and compare them with fine-scale changes in environmental factors, and (3) determine the environmental factors influencing the abundance of Buttonbush.

Study Area

The ten ponds are located in two lowland deciduous forest woodlots within 1.5 km of each other in south Thorold Township, Welland County, Ontario (Ponds 3, 4, 5, 7: 79° 14′N, 43° 05′W; Ponds 1, 2, 6, 8, 9, 10: 79° 14′N, 43° 02′W). Few intact woodlots remain in this predominantly agricultural county. The sites are located on mainly clay soils deposited in the Pleistocene as part of glacial Lake Iroquois floodplains. Upper soil layers are usually greyish to light brown and lie over a reddish gritty clay (Anonymous 1935). The topography is flat, and surface drainage on the sites and in the region is poor.

Soils within the ponds generally contain a 15-25 cm layer of fibric-organic matter over the bluish-grey clay. Soils are moderately to strongly acidic. Water pH varies from 5.5-6.5. The ponds vary in depth (0.4-1.5 m) and size. Dead stumps or mounds within the pond are usually covered with a mat of herbs and shrubs. The adjacent forest floor and the mounds are not flooded. Water levels may decline during the summer months, especially in August.

Fagus grandifolia (American Beech), *Fraxinus americana* (White Ash), and *Acer saccharum* (Sugar Maple) dominate the wetmesic lowland forests, but *Quercus palustris* (Pin Oak), *Acer rubrum* (Red maple), and *Fraxinus pensylvanica* (Green Ash) grow closer to the pond edges. *Cephalanthus occidentalis*, which is at the northern limits of its range in southern Ontario (Fox and Soper 1953), occurs along the edges or occasionally throughout the ponds. One of the woodlots is one of only four sites known for *Carex seorsa* in Canada (Reznicek and Catling 1984).

Methods

Forest ponds with Buttonbush were selected in the fall and spring of 1980 and 1981 where canopy and ground layer disturbances were minimal. Species lists of vascular plants were made for each pond in October 1980 (ponds 1-6) and July and August 1981 (all ponds). Species presence was recorded in each of 4 zones: emergent (always flooded), platform (temporarily flooded), mound (raised areas above water level within the pond), and forest (within approximately 15 m of the platform) (Figure 1). Voucher specimens of plant collections were deposited in the herbarium of the Ecology Laboratory, Erindale College, University of Toronto. Species nomenclature follows Fernald (1950).

Water levels were measured at the center of each pond once in October, 1980, March, May, July, August, October, November, December, 1981, September 1982, and June 1983. Average fluctuation per year was estimated for 1981-1982.

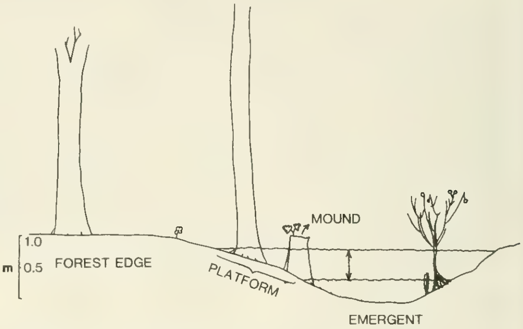

FIGURE 1. A schematic diagram of a Buttonbush pond showing the four zones used in this study to sample ten ponds.

Percent of pond exposed to direct light was recorded twice at midday, in September 1982 and June 1983. Pond size was measured in December 1981.

Soil pits were dug in October 1981 on the platform and in the forest zone. Mound and emergent zone soils could not effectively be sampled. Soil profiles were described and soil samples of the A1 and B horizon were taken from the sides of the pit and composited. Field pH was measured colorimetrically with a Cornell Ecology Test Kit. Soil moisture on the platform was determined gravimetrically. Soil samples were analyzed by the Ontario Soil Testing Laboratory at Guelph for phosphorus, potassium, magnesium, calcium, pH, and texture. Texture was ranked as a combined index from 1 (both A1 and B horizons fine) to 5 (both horizons coarse).

To determine coarse-scale patterns, species constancy (average percent presence) was calculated for each zone over all 10 ponds. To determine fine-scale patterns within the platform zone, presence lists of the platform zone for each pond were compared using ordination. Species occurring on less than three platforms were deleted. The 38 species by 10 platforms matrix was analyzed by detrended correspondence analysis (Hill and Gauch 1980). Relations between the first three axes and pond size, water depth and fluctuation, soil, moisture, and light factors were investigated by Spearman rank correlations.

The response of Buttonbush to environmental gradients was analyzed quantitatively by estimating the average height, width, and length of each *Cephalanthus occidentalis* clump in all ponds. The volume of all clumps per 1000 m^2 of pond surface was calculated. The relation of Buttonbush abundance and species richness of the entire pond (platform and emergent zones) to the environmental factors was investigated with stepwise multiple regression analysis (STEPWISE procedure of SAS 1985).

Results

Coarse-scale trends across zones

Comparison of community composition of the four zones indicated differences in species distributions. *Prunus serotina* (Black Cherry), *Fagus grandifolia, Quercus rubra* (Red Oak), *Fraxinus americana*, and *Acer saccharum* were tree species restricted primarily to the forest zone, as were the shrubs *Ribes cynosbati* (Dogberry), *Amelanchier arborea* (Serviceberry), and *Hamamelis virginiana* (Witchhazel) (Table 1). In contrast, *Cephalanthus occidentalis, Acer sacchar-*

TABLE 1. Distribution of shrubs, trees and vines in the four zones. Species are listed with their constancy values if they attained a constancy of 30% or more in at least one zone. Soil factors for forest and platform zones are summarized below.

	Pond Zone			
Species	Forest	Mound	Platform	Emergent
Prunus serotina	90	10		
Fagus grandifolia	80	10		
Ribes cynosbati	70	10		
Rubus allegheniensis	80	20		
Hamamelis virginiana	80	20		
Amelanchier arborea	60	20		
Lonicera dioica	50	10		
Quercus rubra	50	20		
Betula lutea	50	50		
Rubus idaeus	50	50		
Quercus bicolor	40	—	10	
Rubus pubescens	30	—	10	
Carpinus caroliniana	90	10	20	
Cornus racemosa	80	10	20	
Fraxinus americana	70	10	10	
Acer rubrum	70	20	20	
Rubus hispidus	70	30	20	
Acer saccharum	50	10	10	
Carya ovata	60	20	20	
Rhamnus pungens (I)	50	40	20	
Sambucus canadensis	80	50	60	
Quercus palustris	80	70	80	
Nyssa sylvatica	30	30	30	
Parthenocisus quinquefolia	50	40	60	
Vitis riparia	70	50	50	10
Ilex verticillata	20	50	30	20
Vaccinium corymbosum	30	50	40	10
Rosa palustris	10	30	20	10
Fraxinus pensylvanica	70	30	90	20
Ulmus americana	60	40	70	10
Viburnum recognitum	50	20	50	10
Acer saccharinum	10	80	80	20
Cephalanthus occidentalis		30	90	100
Species richness ($\bar{x} \pm$ SD)	45 (5)	30 (16)	28 (11)	7 (5)
Total species richness	92	114	100	31
Soil Factors ($\bar{x} \pm$ SD)				
Soil Moisture	40 (8.6)	—	58 (9.4)	—*
Texture	3 (1.7)	—	2 (1.6)	—
Phosphorus	16 (17.3)	—	31 (25.4)	—
Potassium	120 (53.0)	—	207 (64.2)	—*
Magnesium	191 (13.0)	—	193 (18.0)	—
Calcium	1430 (358)	—	1645 (352)	—
pH	5.2 (med.)	—	5.9 (med.)	—

(I) = introduced species.
* = significantly different at $p < 0.05$.

inum (Silver Maple), *Ulmus americana* (White Elm), and *Fraxinus pensylvanica* occurred with greater constancy in the platform zone than in the forest zone. *Ilex verticillata* (Winterberry) and *Vaccinium corymbosum* (Highbush Blueberry) had their highest constancy values on the mounds. *Cephalanthus occidentalis* was almost completely restricted to the emergent and platform zones.

Comparison of zones by community coefficient indicated that platform and mound zones were most similar (Table 2). The forest zone was slightly more similar to the mound than to the platform zone but shared almost no species in common with the emergent zone (Table 1 for woody plants). In addition, four herbs were common to forest and emergent zones: *Solanum dulcamara* (Bittersweet), *Leersia oryzoides* (Rice Cutgrass), *Boehmeria cylindrica* (Boghemp), and *Thelypteris palustris* (Marsh Fern). Only 14 of the 105 species encountered occurred in all four zones.

Species richness declined from forest (45 species) to emergent zone (7 species) (Table 1). In conjunction with this decline, community structure became simpler: the forest zone had 14 trees, 12 shrubs and 20 herbs with a constancy $> 50\%$, the mound had 4 trees, 3 shrubs and 6 herbs, the platform had 4 trees, 3 shrubs and 8 herbs, while the emergent had 1 shrub (*Cephalanthus occidentalis*) and 2 herbs.

Soil moisture differed significantly between forest and platform ($t = 4.407$, $p < 0.05$). Nutrient levels measured in forest and platform indicate a potentially richer nutrient environment for the platform zone, although only potassium was significantly higher ($t = 3.29$, $p < 0.05$) (Table 1).

Fine-scale trends within the platform zone

Ordination of the ten platform zone data indicated a compositional gradient ranging from wet-mesic forest species, such as *Cornus racemosa* (Gray Dogwood), *Vitis riparia* (Riverbank Grape), *Solanum dulcamara, Geum laciniatum* (Rough Avens), and *Parthenocissus quinquefolia* (Virginia Creeper), to wet habitat species, such as *Carex seorsa* (Divided Sedge), *Boehmeria cylindrica,* Osmunda regalis (Royal Fern), *Carex stipata* and *Vaccinium corymbosum* (Figure 2). The first axis accounted for 26.1% of the variation, the second axis 8.1%, and the third 1.5%.

TABLE 2. Coefficient of community values for the forest, mound, platform, and emergent zones in the Buttonbush ponds. A quantitative index using species constancy values was calculated with the formula 2w/a+b (Whittaker 1975).

	Forest	Mound	Platform	Emergent
Forest	—	54.0	49.5	7.8
Mound		—	64.0	27.4
Platform			—	28.6
Emergent				

Spearman rank correlations of the environmental factors with the first three axes of detrended correspondence analysis (DCA) indicated that water fluctuations, soil moisture, and pond size were correlated with the first DCA axis ($p < 0.05$, Table 3). As water fluctuations increased, soil moisture and pond size decreased. No correlations were significant for the second or third axis.

Factors influencing Buttonbush abundance

Stepwise multiple regression suggested that only depth of water was a significant factor influencing Buttonbush abundance ($R^2 = 0.52$, $F = 8.56$, $p < 0.05$). Abundance values increased as much as 10 fold with increasing depth, and while there was considerable variation in abundance at greater depths, maximum abundance values may not have been reached (Figure 3). Minimum water depth for successful maintenance of Buttonbush populations appears to be greater than 0.5 m.

Discussion

Community composition is very different between forest and emergent zones, reflecting the steep environmental gradients between moist forest floor and inundated habitats. The platform and mound zones provide intermediate habitats, with the mound more similar to forest because areas remain above the high water level. Other environmental factors not measured across all four zones, e.g. light, may also affect species distribution across the zones. Community structure is more simple and diversity very low with permanent inundation (emergent zone). Decline in diversity from forest edge to emergent zone is primarily a result of loss of species that can tolerate inundation, with few new species being added. Thus, the Buttonbush ponds generally contain a simpler floristic composition when compared to adjacent forest edge. How the forest edge and ponds differ from the rest of the lowland forest area is not known.

When trends within the platform zone were analyzed separately, subtle changes in species distribution between sites could be detected. A primary compositional gradient from wet-mesic forest species to those of wet habitats were correlated with decreased water fluctuations and increased soil moisture and pond size. Thus, while the platform zone may be characterized broadly as that zone where water levels fluctuate (in comparison to the forest zones where no flooding occurs, and the emergent zone where flooding is permanent), it is in turn further affected by the degree of water fluctuation. These compositional

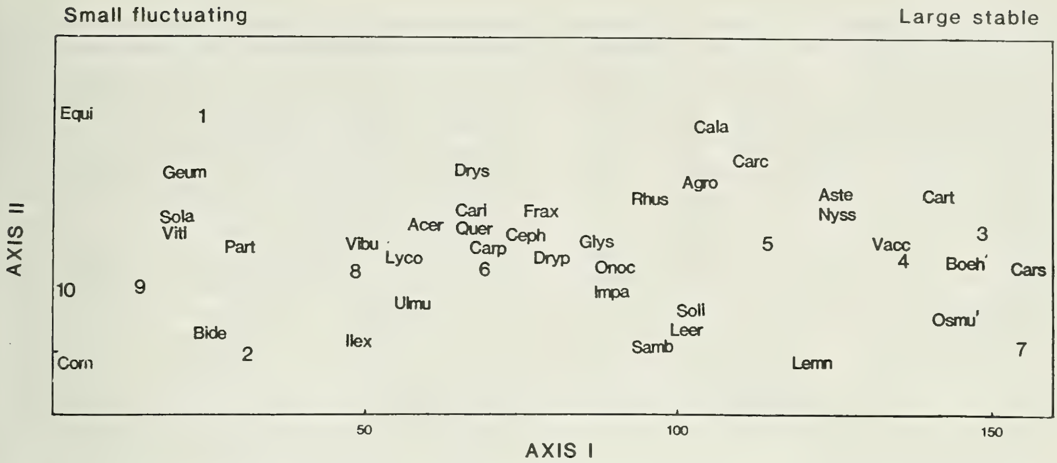

FIGURE 2. Ordination of species and stands by detrended correspondence analysis showing axes 1 and 2. An environmental interpretation of the first axis is indicated above the ordination based on the rank correlations presented in Table 3. Numbers refer to stand numbers as in Table 3. Abbreviations correspond to the species names as follows: Acer = *Acer saccharinum*, Agro = *Agrostis perennans*, Aste = *Aster lateriflorus*, Bide = *Bidens frondosa*, Boeh = *Boehmeria cylindrica*, Cala = *Calamagrostis canadensis*, Carc = *Carex crinita*, Cari = *Carex intumescens*, Carl = *Carex lacustris*, Carp = *Carex projecta*, Cars = *Carex seorsa*, Cart = *Carex stipata*, Ceph = *Cephalanthus occidentalis*, Corn = *Cornus racemosa*, Dryp = *Dryopteris palustris*, Drys = *Dryopteris spinulosa*, Equi = *Equisetum arvense*, Frax = *Fraxinus pensylvanica*, Geum = *Geum laciniatum*, Glys = *Glyceria striata*, Ilex = *Ilex verticillata*, Impa = *Impatiens capensis*, Leer = *Leersia oryzoides*, Lemn = *Lemna minor*, Lyco = *Lycopus uniflorus*, Nyss = *Nyssa sylvatica*, Onoc = *Onoclea sensibilis*, Osmu = *Osmunda regalis*, Part = *Parthenocissus quinquefolia*, Quer = *Quercus palustris*, Rhus = *Rhus radicans*, Samb = *Sambucus canadensis*, Sola = *Solanum dulcamara*, Soli = *Solidago rugosa*, Ulmu = *Ulmus americana*, Vacc = *Vaccinium corymbosum*, Vibu = *Viburnum recognitum*, Viti = *Vitis riparia*.

trends indicate that, while distinguishing zones along steep gradients in the field can helpful, fine-scale environmental differences between sites within a zone will increase the variability of its composition.

The restriction of the rare sedge, *Carex seorsa*, to the platform of more permanently flooded ponds (it also occurred on two mounds and one forest edge in the same three ponds) indicates the importance of a constantly wet habitat in determining its distribution. In Canada, it is only known from three other nearby localities (Reznicek and Catling 1984), where it is found on peaty edges of woodland pools (Argus and White

TABLE 3. Summary of environmental measures and species richness of the platform zone. Stands are arranged by first axis scores of detrended correspondence analysis (DCA). FPH = Field pH, DEPTH = Depth of pond at deepest point, FLUC = Mean Fluctuation in water level, 1981, 1982, SOILM = Percent soil moisture of platform, LIGHT = Percent of pond receiving light at noon, SIZE = Size of pond, CALC = Calcium concentration, TEX = Texture rank from 1 (fine) to 5 (coarse), SPECIES = Number of species recorded in platform and emergent zones, DCA1 = Spearman rank correlation of each factor with the first axis of DCA.

	Stand Number										
Factor	7	3	4	5	6	8	2	1	9	10	DCA1
FPH	4.9	5.7	4.8	5.3	5.9	5.9	5.8	6.2	5.8	5.6	-0.512
DEPTH cm	100	125	100	85	85	40	100	90	100	67	0.439
FLUC cm	6	3	6	21	18	21	27	36	40	67	-0.796**
SOILM %	70	72	56	71	59	49	54	52	55	47	0.806**
LIGHT %	70	85	87	17	63	72	90	17	25	20	0.395
SIZE m2	1450	1700	1450	750	1450	650	525	675	550	625	0.772**
CALC ppm	1625	2000	1850	1250	1250	2000	1975	1950	1400	1150	0.281
TEX 1-5	1	2	1	3	5	1	5	3	3	5	-0.623
SPECIES	29	44	60	22	27	26	35	28	21	21	

**$p < 0.01$ for Spearman rank correlation.

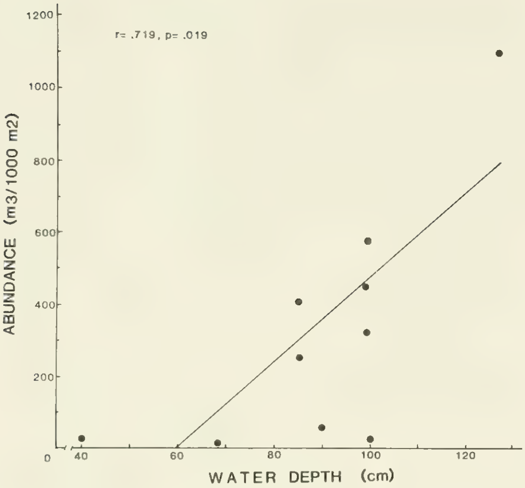

FIGURE 3. Abundance of *Cephalanthus occidentalis* plotted against water depth of pond, with Spearman correlation (r) and linear regression line.

1982). In the United States it is found primarily in the Atlantic Coastal Plain, typically in wet woods and swamps (Fernald 1950).

Nutrient concentrations showed no correlations with the DCA axes or Buttonbush abundance, confirming suggestions in other studies that soil chemistry may not be a limiting factor in inundated habitats; rather, the effect of soil moisture or oxygen levels is probably more critical (Keeley 1979; Robertson et al. 1984; Mitsch and Gosselink 1986). We suspect that Buttonbush responds favourably to increased water depth partly because fewer tree species can tolerate these depths. The flooded environment requires specialized adaptations, especially for low oxygen levels, and few species have such adaptations (Keeley 1979).

An indirect effect of flooding is that tree canopy closure is probably slowed and higher light levels on the pond are maintained. Conner et al. (1981) noted that canopy gaps made possible the invasion of Buttonbush into swamp sites. Our analyses of the effects of light on platform species distribution and Buttonbush abundance were not significant. Degree of shading in floodplain-like habitats may have negligible effects on woody understory composition (Robertson et al. 1984), but may limit growth (Conner et al. 1981; Duever and Riopelle 1983) and reproduction. Menges and Waller (1983) found that light was important in differentiating herbaceous guilds (high-light specialists, light generalists, etc.) only when flooding was infrequent. Buttonbush responds favourably to increasing levels of light, but high levels are not critical for establishment (Faber-Langendoen and Dina 1987). Rather, tolerance of a stressful habitat and the absence of competition appear to be more important. Thus, where ponds occasionally go completely dry, tree seedlings can more easily establish and eventually overtop Buttonbush shrubs.

Our study highlights the different scales of gradients affecting Buttonbush ponds. The use of a coarse-scale environmental gradient distinguished species that could not tolerate inundation from those that could. Buttonbush was found to be very tolerant of flooding. Examination of a fine-scale gradient on the platform indicated that species exhibited a range of tolerances to frequency of flooding, with some species preferring almost complete inundation (*Carex seorsa, Boehmeria cylindrica*), others almost no inundation (*Cornus racemosa, Geum laciniatum*). *Cephalanthus occidentalis* abundance was correlated with increasing depth of the pond. Although additional factors of site history-successional state of the ponds and competitive interactions with other species needs to be considered, examination of these species along environmental gradients provides a good first approximation to factors regulating their distribution and abundance.

Acknowledgments

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Fowler's Toad, *Bufo woodhousii fowleri*, in Canada: Biology and Population Status*

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Fowler's Toad, *Bufo woodhousii fowleri*, is widespread throughout the eastern United States but is restricted to sandy or rocky points and sandy beaches along the northern shore of Lake Erie (Ontario) in Canada. Beetles and ants are its major food and garter snakes its major predator. Adults are primarily nocturnal and active at between 14° and 25°C. They breed from early May to mid-June in marshy shallows adjacent to sand dunes, savannah or open forest. Clutch size is 4000 to 10 000. Tadpoles transform by the end of July. Males first breed as two-year-olds at 50 mm snout-vent length, females are older and larger at first laying. Although the species has disappeared from at least two sites at the western end of Lake Erie within the last 30 to 40 years, and is discontinuously distributed, it appears to be stable at most recorded localities and abundant at Long Point. Hybridization with the American Toad, *B. americanus*, is recorded widely in the United States but confirmed only at Long Point in Canada, and introgression is insignificant there. Many areas where it occurs are within parks or other managed lands where there seem to be no immediate threats from industry or other development. However, it has disappeared from one intensively used park (Point Pelee) and an agricultural area with a heavy chemical use (Pelee Island). This toad is classified as *Rare* in Canada because of its restricted distribution, which makes it vulnerable to further habitat loss.

Key Words: Fowler's Toad, *Bufo woodhousii fowleri*, biology, status, Canada, Ontario, habitat, predation, reproduction, habits, distribution.

Fowler's Toad, *Bufo woodhousii fowleri*, (Figure 1) is a widespread species in eastern North America but barely enters southern Canada along Lake Erie. It is one of a number of amphibian species which occur within the Carolinian forest zone in southern Ontario. Some others, the Cricket Frog (*Acris gryllus crepitans*), Eastern Tiger Salamander (*Ambystoma t. tigrinum*), Smallmouth Salamander (*A. texanum*) are increasingly threatened by habitat reduction in this northernmost part of their natural range (*see* Cook 1977, 1984.)

Bufo woodhousei fowleri has had a complicated nomenclatorial history (Barbour and Loveridge 1929; Myers 1931; Dexter 1966, 1970; Kluge 1983). The name dates from Hinckley's (1883) publication of a description of the tadpole. She credited the name to Putman but the latter's 1863 description of adults from Danvers, Massachusetts collected by the naturalist S. P. Fowler was never published. It is invalid for dating the name, though Cope (1875, 1889) and Garman (1884) had also used it. Fowler's Toad is now generally considered to be a subspecies of Woodhouse's Toad, *B. woodhousii*, the prairie form, based on Meacham's (1962) studies of its hybridization with *B. w. woodhousii*. A third form in the complex, *B. w. australis*, is recognized in the southwestern position of the range (Conant 1975; Stebbins 1985).

Adult *B. w. fowleri* are 50-80 mm SVL (snout-vent length) (Logier 1931, 1952; Wright and Wright 1949; Conant 1975), females are slightly larger than males. They are grey or buffy coloured above with darker patches and numerous small dark brown warts on a granular textured skin (Dickerson 1906; Ruthven 1917; Myers 1927; Netting 1929; Wright and Wright 1949; Logier 1952; Cochran 1961; Conant 1975; Smith 1978; Froom 1982; Green 1984; Cook 1984; *see* Figure 1). There are usually three or more warts per dark dorsal spot. The undersurface is white or cream coloured and is either without spots or with a single dark pectoral spot situated between the forelimbs. The throat is dark in males but white in females. The snout is short and blunt and the bony cranial crests on the head are weak.

The call has been described variously as a droning scream, wail, bleat or moan (Allard 1916;

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*Rare status assigned by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1986. The original report on which this paper is based, D. M. Green 1985. The biology and population status of *Bufo woodhousii fowleri* (Fowler's Toad) in Canada. 42 pp., is available at cost from The Canadian Nature Federation, Ottawa, Ontario. Status changed to Vulnerable by COSEWIC, April 1990, as part of transfer of all species previously designated Rare to this new category.

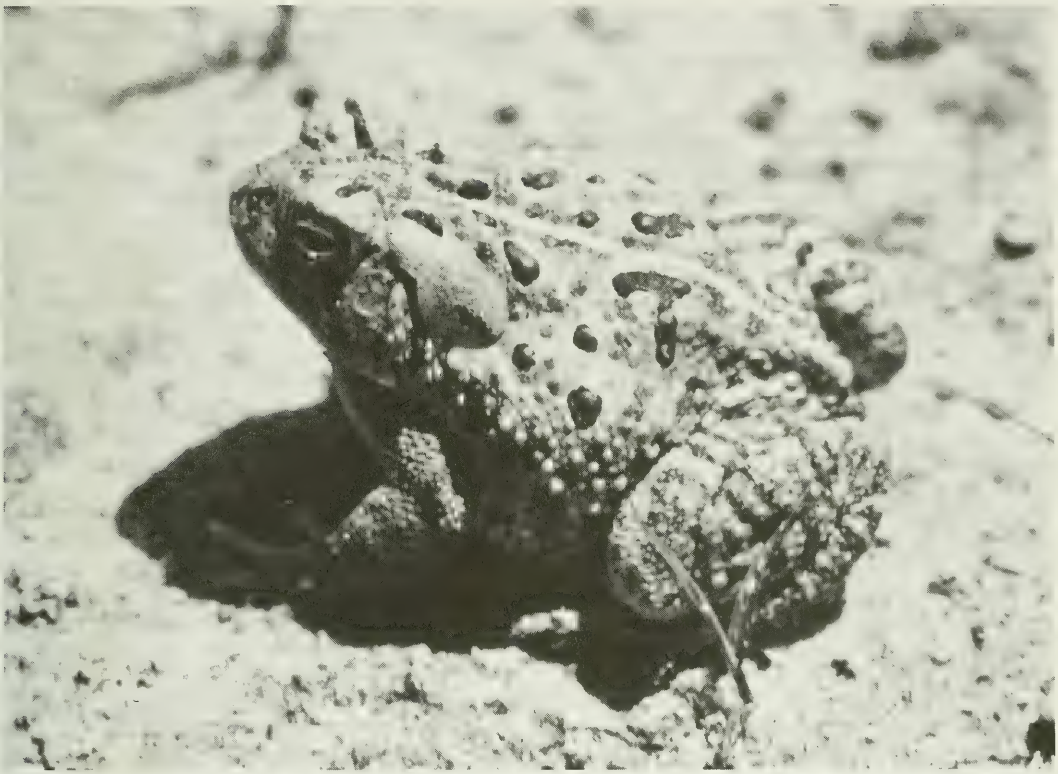

FIGURE 1. *Bufo woodhousii fowleri* (male). Individual from Point Albino, Ontario, 10 July 1980 (NMC 21959). Photograph by the author.

Wright and Wright 1949). It typically lasts for only 1 to 2 seconds, depending upon temperature (Zweifel 1968; Green 1982). Structurally, the call consists of a series of pulses on a single dominant frequency. Pulse rate increases and call duration decreases as the temperature of the animal increases (Zweifel 1968).

The eggs are laid in long strings in a single tube of jelly about 2.6 to 4.6 mm in diameter (Wright and Wright 1949). No partitions separate the individual ova within the jelly sleeve. The eggs themselves are black above with a grey vegetal pole and are 1.0 to 1.4 mm in diameter.

The tadpoles are typical bufonid tadpoles with an emarginate oral disc, serrate subequal jaws with keratinized sheaths, medial anus, sinistral spiracle, a low tail fin, dorsally placed eyes, two labial tooth rows on the upper labium and three labial tooth rows on the lower labium (Hinckley 1883; Wright and Wright 1949; Altig 1970). They are mottled black in colour and do not exceed 27 mm in total length. The ratio of tail height to tail musculature height is more than 2.00 (Altig 1970).

Habits

Fowler's Toads are most active in the evening (Higginbotham 1939; Clarke 1974a) at about 14°C to 25°C, and tend to become dormant at higher temperatures (Hadfield 1966). Nerzig and Hainsworth (1978) reported that *B. w. fowleri* chose lower than optimal temperatures at which to digest food. Martof (1962) found that between about 19°C and 25°C, Fowler's Toads were predominantly photopositive in their movements through a simple maze, but photonegative at temperatures both above and below this range. They also tended to hop rather than crawl within this temperature range and to react more quickly.

During the day, the toads will bury themselves in the sand or hide under leaf litter and debris (Adams and Clark 1958; Hadfield 1966; C. A. Campbell. 1979. Preliminary herpetological survey and evaluation of proposed habitat alterations at Big Creek National Wildlife Area, Port Rowan, Ontario. Unpublished report to Canadian Wildlife Service). They will, on occasion, bask in shallow depressions in the sand (Hadfield 1966). Clarke (1974a) found that individual toads in a Connecticut population were rarely active two nights in succession and that they occupied summer home ranges of about 21 to 32 m in diameter. Individuals occupied the same home range each summer. Juveniles tended to be more diurnal and less terrestrial than adults (Clarke 1974a).

Fowler's Toads hibernate terrestrially during the winter. They burrow into the sand below the frost line under debris and leaf litter. They are active in Ontario for no more than six months of the year (May through October) at Long Point (J. T. Planck. 1981. Amphibian and reptile distributions along the proposed Gravelly Bay walking trail, Long Point National Wildlife Area. Unpublished report to Canadian Wildlife Service). In Connecticut, Clarke (1974a) found *B. w. fowleri* to be active only from May through September.

The most frequent prey taken by adult Fowler's Toads are beetles (Coleoptera) and ants (Hymenoptera), but other insects, especially bugs (Hemiptera), as well as sowbugs (Oniscoidea) and spiders are also taken (Metcalf 1921; Smith and Bragg 1949; Barbour 1953; Bush 1959; Bush and Menhinick 1962; Klimstra and Myers 1965; Lathan 1968; Clarke 1974b; Labanick and Schleuter 1976a). Bush and Menhinick (1962) reported that insects comprised 95.3% of all food items identified and that beetles and ants alone constitued 85.1% of the total. Clarke (1974a) observed that juveniles were active predators, whereas adults tended to adopt a sit and wait strategy. Juveniles ate mostly very small insects, especially Collembolans (springtails) and aphids (Clarke 1974b).

There have been few physiological studies of *B. w. fowleri*. Claussen (1974) investigated water balance and urination and confirmed the expected relationship of increased bladder capacity with increased terrestrialism as compared to a frog, *Rana clamitans*.

Predation

Snakes, particularly garter snakes, *Thamnophis*, are the chief predators of toads. Common Garter Snakes, *T. sirtalis*, are quite abundant on Long Point. Hognose snakes, *Heterodon*, although now rare in Ontario, are specialized toadeaters (Edgren 1955; Smith and White 1955). Surface (1906) reported that 75% of the diet of Pennsylvania *Heterodon platyrhinos* consisted of toads. Water snakes, *Nerodia*, are also predators of toads. Although toads, because of their noxious and toxic skin secretions, are generally unpalatable to most potential predators, such as Bullfrogs, *Rana catesbeiana* (Brown 1974; Tucker and Sullivan 1975), *Thamnophis, Nerodia* and *Heterodon* have substantial tolerance of *Bufo* skin toxins (Licht and Low 1968). Snakes also account for considerable mortality among tadpoles and toadlets. Some birds such as shrikes, bitterns or owls have also been observed to take Fowler's Toad (Lathan 1970, 1971a, 1971b). Fowler's Toads are also parasitized by nematode worms (Jilek and Wolff 1982) but I have seen no data on mortality rates caused by such infections.

Fowler's Toads avoid predation chiefly by digging out of sight or by camouflage. The light grey, mottled dorsum blends in well with a sandy substrate. Toads will often remain immobile when disturbed (Dodd 1977), especially when threatened by snakes. The usual fright reaction of a toad is to inflate its lungs, elevate its body and lower its head towards the potential threat.

Toads are often injured by potential predators. Clarke (1975) found a high proportion of the adult Fowler's Toads in his study population exhibited scars or other evidence of injury. He concluded that the foul taste of the toad's skin secretions would deter actual consumption of the toad by a predator.

Reproduction and Growth

Fowler's Toads congregate at breeding sites in May and June. Toads will migrate there, often crossing roads, which may significantly contribute to annual mortality (R. B. Walker. 1980. Road kills on the causeway, Long Point, Ontario, 1979, 1980. Unpublished report to Canadian Wildlife Service). Breeding congregations in Canada have been observed as early as 3 May 1980 at the western end of Long Point (Green 1981), but I did not observe full choruses in 1984 until 30 May and in 1985 until 11 May. Logier (1931) first observed calling in 1927 on 30 May at Long Point. From my own observations, calling will typically not commence at temperatures below 14°C. Calling Fowler's Toads usually can be heard at Long Point until early June. At Point Abino, and nearby Windmill Point, chorusing typically begins a few weeks later in the year. Calling toads were encountered at Point Abino on 19 May in 1980 but not until 8 June in 1978 (Green 1981) and 6 June in 1985. Breeding activity of *B. w. fowleri* has been observed in late April in Maryland (Grogan and Bystrak 1973) and lasts for about three weeks, as observed in Connecticut (Clarke 1974a).

At any one time, breeding congregations will be comprised chiefly of chorusing males (Aronson 1944; Jones 1973; Zweifel 1968). Toads find their way to breeding sites using both olfactory cues (Grubb 1973) and celestial cues (Landreth and Ferguson 1968) for orientation, as well as the calls of males already present at the site. McKeown (1968) found that celestial orientation was functional even in young tadpoles five days after hatching and was used by the larvae to find water of appropriate depth.

The "mating" or aggregation call of *Bufo* attracts other toads to a breeding site (Wells 1977). Males will also announce their sex if clasped by another male by emitting a "warning chirp" accompanied by a "warning vibration" (Aronson 1944). Mating calls vary with temperature; as it goes up, call pulse rate increases and call duration declines (Zweifel 1968). Dominant frequency is more closely correlated with body size. Woodward (1982) noted that in *B. w. woodhousii*, larger males were more successful in securing mates. Fairchild (1981) concluded that larger males of *B. w. fowleri* would select cooler temperatures which would presumably enhance the attractiveness of their calls to females, arguing that females prefer larger, lower voiced males. Working with *B. w. australis*, Sullivan (1982, 1983) found, however, that increased call frequency was more attractive to females regardless of temperature and that only call frequency was correlated with male body size or with male mating success.

Female *B. w. fowleri* may lay 4 000 to 10 000 eggs (Wright and Wright 1949; Clarke 1974a). I counted 2813 eggs in one ovary of a 60 mm SVL (Snout-vent length) female from Pt. Abino in June 1985, indicating a total of about 5600 eggs. Larger females produce greater numbers of eggs (Clarke 1974a). The tadpoles may form dense schools in shallow water (Wright and Wright 1949; Breden et al. 1982) and metamorphose into toadlets 11 to 14 mm SVL in mid-June (Minton 1972; Labanick and Schleuter 1976b). I observed recently metamorphosed juveniles of *B. w. fowleri* in July and August on sandy beaches or nearby dunes at Long Point and Point Abino. Logier (1931) reported recently transformed individuals present at Long Point on 13 July 1929 and Latham (1971c) observed young juveniles in mid-August on Long Island.

First-year growth is very rapid (Labanick and Schleuter 1976b; Claussen and Layne 1983). Clarke (1975) reported an average 6.58 fold increase during the first year in Connecticut. Labanick and Schleuter (1976b) calculated an average growth rate of 0.36 mm S-V per day for the first two months after transformation. Females grow significantly faster than do males and thus reach a larger size (Clarke 1975). Males in Indiana begin to show secondary sexual characteristics about one year after metamorphosis. Females attain adult size about one month later but also at two years of age (Breden 1987).

B. w. fowleri appears to have a potential life span of 3 to 5 years (Clarke 1977). The Philadelphia Zoo maintained a wild-caught adult for two-and-a-half years (Bowler 1975). Clarke (1977) found 30% annual survival among postmetamorphic individuals at a site in Connecticut; highest mortality was among young-of-the-year juveniles prior to their first winter. Among 17 000 electrophoretically identified tadpoles introduced into an Indiana population, Breden (1987) recovered 8539 postmetamorphic toadlets and, of these, recaptured 37 as breeding adults.

Habitat

Throughout most of its range in North America, *B. w. fowleri* shows a preference for sandy habitats of lake shores, river banks, beaches and coastlines (Wright and Wright 1949; Cory and Manion 1955; Jones 1973; Zweifel 1968; Breden 1987). It tends to breed in shallow regions of permanent bodies of water. Clarke (1974a, 1974b, 1975, 1977) studied *B. w. fowleri* at a golf course pond in Connecticut while Jones (1973) studied populations at artificial reservoirs in Indiana. All Ontario observations within the last 30 years have been made at shorelines, peninsulas, bays and inlets along Lake Erie. Unsuitable habitat, (i.e. shoreline bluffs and rocky beaches) such as occurs along the coast of Elgin County (Figure 2), may isolate populations, primarily by lacking suitable breeding sites.

At Point Abino and Windmill Point, I have observed Fowler's Toads calling from patches of reeds (*Scirpus*) or sedges (*Carex*) along the lake beach (Green 1981), but not from the open sandy beach. F. W. Schueler (personal communication) has also noted Fowler's Toads calling from the rocky beach at the south tip of Point Abino. At Rock Point, Fowler's Toads called from rocks by the water or from floating mats of filamentous green algae (*Cladophora*) just off shore (Green 1981). The pond used by the toads at Port Maitland has been formed by a partial breakwater off the east shore of the mouth of the Grand River where it empties into Lake Erie. The toads called from the sides of this pond among rushes (*Juncus*) and cattails (*Typha*).

At Long Point, an extensive area of marsh covers many hectares along the north side of the point facing Long Point Bay (Bayley 1979). The dominant plants in this marsh are cattails (*Typha*), sedges (*Carex*), rushes (*Scirpus*) and reed grass (*Phragmites*). I have observed Fowler's Toads calling from reed patches scattered throughout the Crown Marsh area at the western portion of Long Point (Green 1982) while Logier (1931) found males calling from shallow sand bar pools.

Toads may be encountered near the breeding sites but apparently also disperse throughout the surrounding areas. Breden (1987) documented considerable adult migration between adjacent breeding sites from one year to the next in Indiana. Immediately post-metamorphic juvenile toadlets may be abundant in July or August along the lake shore beach at Long Point (Schueler 1981).

Distribution

Bufo w. fowleri inhabits much of North America east of the Great Plains (Figure 2). The considerably larger, more western *B. w. woodhousii* intergrades with *B. w. fowleri* along a line south from Lake Michigan to the coast of the Gulf of Mexico at the Texas/Louisiana border (Meacham 1962). *B. w. fowleri* appears to be absent from the southern Atlantic coastal plain from the Carolinas to the Appalachicola region of Florida, including peninsular Florida (Conant 1975).

Bufo w. fowleri is documented in Canada only from 19 localities in extreme southern Ontario along the northern shore of Lake Erie [Figure 2] (*see* Logier 1925, 1931; Evans and Roecker 1951; Adams and Clark 1958; Logier and Toner 1955, 1961; Green 1981). It was first collected in Ontario in 1894 (Canadian Museum of Nature: NMC 41: Long Point) but it was not reported from the province until Logier (1925) recorded it for Point Pelee, based on specimens collected in 1920 (Royal Ontario Museum: ROM 104, 105), but it had been collected there even earlier, in 1913 (NMC 543, 555, 545).

Recent investigations have failed to find *B. w. fowleri* in Essex County. There have been recent records of Fowler's Toads at Erieau, Welland County, from McGeachy Pond. Although Campbell (1969) noted Fowler's Toads at Rondeau Park in Kent County, this needs confirmation. Although *B. americanus* remains fairly common on Point Pelee, *B. w. fowleri* has not been recorded there since 1949, nor on Pelee Island since 1960 (Canadian Museum of Nature).

Some previously accepted localities may be deleted from the probable range. A single specimen from Dorcas Bay, Bruce Co. (ROM), listed as *B. w. fowleri* by Logier and Toner (1961), has been reidentified as *B. americanus* by W. Weller and DMG. A record from Simcoe (Haldimand-Norfolk Co.) is listed by Logier and Toner (1961) citing the private collection of M. Landon. No collection data are given with this specimen and it is the only record from this locality. A record from Wainfleet Marsh is also questionable (F. W. Schueler, personal communication). Suitable habitat for *B. w fowleri* is lacking at Wainfleet, although the Lake Erie shore is close by. A single toad from Bothwell (Kent Co.) near the Thames River deposited at the Canadian Museum of Nature (NMC 13458) and orginally identified as *B. w. fowleri* has been examined independently by F. R. Cook and DMG and is almost certainly *B. americanus*. Only newly transformed juveniles (toadlets) of *B. w. fowleri* have been reported from Port Burwell (Elgin Co.). Toadlets and tadpoles of *B. w. fowleri* and *B. americanus*, which are often sympatric, are extemely difficult to distinguish and records based solely on these should not be accepted.

A record from Morpeth, Kent Co., near the eastern base of Pointe aux Pins (Rondeau), has no indication whether the specimen came from the village itself or, as is more likely, from the nearby Lake Erie coast.

Hybridization with *Bufo americanus*

B. w. fowleri is a member of the *Bufo americanus* species group (Blair 1972), seven or more closely related taxa variously treated as species or subspecies, among which hybridization is common (*see* Volpe 1960; Blair 1972; Green 1981, 1983, 1984; Cook 1983). All are cytogenetically very similar (Schmid 1978). *B. w. fowleri* is known to hybridize naturally with the American Toad, *B. americanus*, Southern Toad, *B. terrestris*, and with a toad in a different species group, Gulf Coast Toad, *B. valliceps* (Blair 1972; Volpe 1952, 1958, 1960).

B. americanus is generally larger than *B. w. fowleri* and commonly has a profusely spotted venter and comparatively large warts (Wright and Wright 1949; Green 1984). Although northern populations of *B. americanus* may have many warts per dark dorsal spot (Cook 1983), there are usually only one or two warts per spot in populations sympatric with *B. w. fowleri*. The morphological differences between the two species are summarized by Wright and Wright (1949) and Zweifel (1968). They also smell differently (Miller and Chapin 1910), a reflection of the differences in skin toxins and other compounds (Pollard et al. 1973; Mahan and Biggers 1977). Biochemical differences have been analyzed by Brown (1964) and by Green (1984). The call of *B. americanus* is a long pulsed trill easily distinguished from the bleat of a Fowler's Toad (Zweifel 1968; Green 1982).

Hybrids between *B. americanus* and *B. w. fowleri* have been noted in various places in eastern North American since early this century (Allard 1908; Miller and Chapin 1910; Hubbs 1918; Myers 1927; Pickens 1927; Blair 1941; Volpe 1952; Cory and Manion 1955; Brown 1964; Zweifel 1968; Jones 1973), including Ontario (Green 1981, 1982, 1984). The two species have different habitat preferences: *B. w. fowleri* prefers sand dunes and beaches, *B. americanus* inhabits more wooded areas. At Point Abino in 1978, 1980 and 1985, I observed *B. w. fowleri* calling only from the shore of Lake Erie while the majority of *B. americanus* present were calling from ponds in the forest within the point. At Long Point, both species share the same breeding site in Long Point Marsh and for a limited time each year (in early May) will be present and calling simultaneously. *B. americanus* usually breeds earlier than does *B. w. fowleri*, but there is frequently a period of overlap. At this time, hybrid males may also be present and calling. This sequence has also been observed among populations in Indiana (Blair 1941) and New Jersey

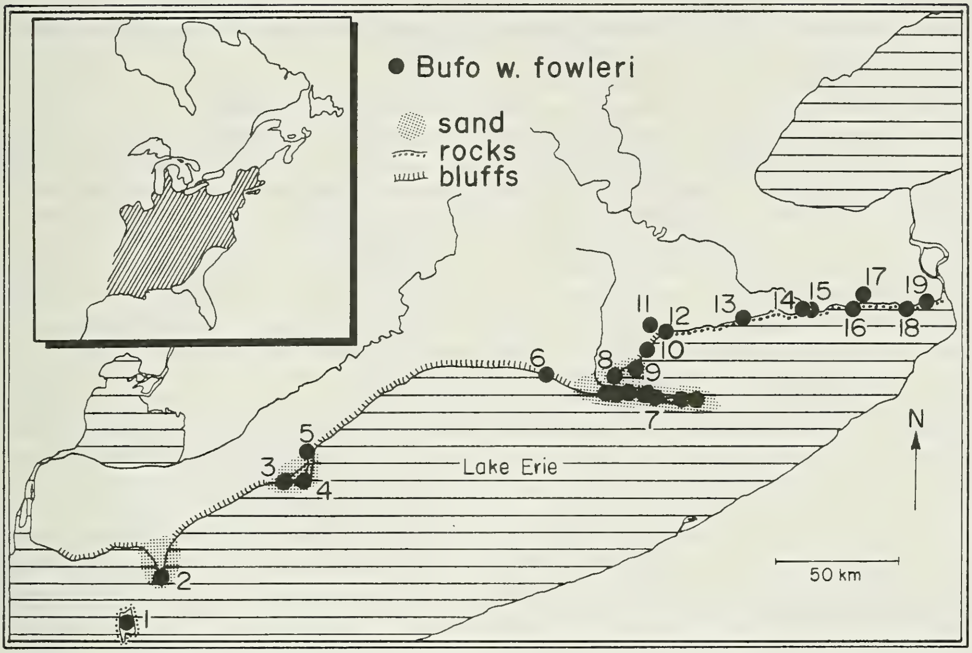

FIGURE 2. Sites of known or purported records of *Bufo w. fowleri* in southern Ontario. The distribution of sandy shores, rocky shores and shoreline bluffs along the northern shoreline of Lake Erie is also indicated (*adapted from* Dean 1969). Note the absence of Fowler's Toad records from areas of shoreline bluffs, except at the mouths of some creeks. 1) Pelee Island, 2) Point Pelee, 3) Erieau, 4) Rondeau, 5) Morpeth, 6) Port Burwell, 7) Long Point and Big Creek, 8) Port Rowan, 9) Turkey Point, 10) Fisher's Glen, 11) Simcoe, 12) Port Dover, 13) Featherstone Point, 14) Port Maitland, 15) Rock Point, 16) Burnaby Beach, 17) Wainfleet Marsh, 18) Point Abino, 19) Windmill Point. Inset shows range of Fowler's Toad in North America (*after* Conant 1975). No firm boundary is shown in the southwestern part of the range due to the zone of intergradation with *B. w. woodhousii* in that area.

(Zweifel 1968). I have encountered mixed choruses with numerous hybrids present on 3 May 1980 and 5 May 1981 at Long Point. At only three other sites along Lake Erie in Ontario have both species recently been observed calling together: Rock Point, Point Abino, and Featherstone Point. I have encountered hybrids at Long Point every year from 1977 to 1981 and 1984 to 1986.

The ecological and temporal separation of *B. w. fowleri* and *B. americanus* is probably sufficient to isolate them (Cory and Manion 1955). Although the few hybrids that are found appear to be viable and fertile (Green 1981, 1984, unpublished data), introgression appears to be limited (Green 1984). Twenty-one hybrid toads examined from Long Point from 1977 to 1981 were determined to be principally, if not exclusively, F1 progeny on the bases of biochemical and acoustic data (Green 1981, 1982, 1984). Jones (1973, 1975) found no hybrids one year in a locality in Indiana where hybridization had occurred previously (Blair 1941) and concluded that the hybrid zone had dissipated and interspecific isolating mechanisms had been reinforced. Loftus-Hills (1975) disputed such an interpretation. At Point Abino, where both *B. w. fowleri* and *B. americanus* occur, Lake Erie warms much later than it does at Long Point Bay (M. S. W. Bradstreet. 1977. The biological environment of Long Point, Lake Erie: An overview. Unpublished report to Nature Conservancy of Canada. 159 pages), Fowler's Toads breed much later and hybrids have not been recorded. It appears that the extent of hybridization may vary year to year and locality to locality depending upon local conditions.

Canadian Populations: Sizes and Trends

At present, the only available data on population sizes are estimates of the numbers of calling males in breeding choruses based on field observations. A rough estimate can be made of the numbers of mature adult males and, considering the 1:1 sex ratio (Blair 1972), the effective population size might be derived from these observations. At Port Maitland in 1980, I collected 14 adult males (NMC), and there may have been 20 actually present in the pond. This would indicate an approximate population size of about 30 to 40 adult toads. Similarly, I would estimate the following sizes for other known populations: Long Point (vicinity of Long Point Provincial Park) — 600 to 1000 individuals; Featherstone Point — 2 to 6 individuals; Rock Point — 10 to 15 individuals; Point Abino — 75 to 100 individuals; Windmill Point — 30 to 50 individuals. Rock Point and Port Maitland are so close together that the toads there may constitute a single population. Population estimates for Erieau, Rondeau and Turkey Point were not possible as these sites have not been adequately surveyed in recent years. Three individuals were collected at Erieau by the author in 1978 (NMC) and others were heard calling. Toadlets of uncertain identity were also collected at Erieau in 1973 and 1975 but otherwise only *B. americanus* have been found there recently. That populations of *B. w. fowleri* remain at Point Pelee and Pelee Island presently appears doubtful. Large numbers of toads were reported at Turkey Point in the 1930s and 1940s but the last record was in 1956. W. Weller (personal communication) reports that in June of 1973 he neither saw nor heard any Fowler's Toads at Turkey Point even though they were common at Long Point on the same evening.

The population estimate for Long Point is based only on toads observed calling at the western base of the point. Fowler's Toads are known to be common at the eastern tip of the point from Bluff Point east (Schueler 1981; K. D. Dewey. 1981. Fish inventory, hydrographic mapping, biolimnological sampling, bird, reptile, amphibian and large mammal utilization of six inland ponds in the Gravelly Bay Area of Long Point National Wildlife Area. Unpublished report to Canadian Wildlife Service. 70 pages; J. Planck, personal communication) but I have no estimates of chorus sizes. Fowler's Toads, however, are not common in the middle portion of the point around Squires Ridge (J. Planck, personal communication).

Populations of *B. w. fowleri* at Long Point appear to have been stable in numbers over the last 50 years as reasonably large numbers occurred there in 1927 and 1948 (ROM). Logier (1931) stated that they were quite common, Evans and Roecker (1951) considered them to be widely distributed and J. S. Bleakney and F. R. Cook (Unpublished data, Canadian Museum of Nature) found it to be common in 1956. Large numbers still exist there. Populations at Point Pelee and at Rondeau appear to have declined or disappeared. There are few records from Rondeau, but apparently sizeable numbers were at Point Pelee in 1937 (ROM). Fowler's Toads appear to have been present at Port Maitland for the past 50 years. Records are too sketchy to indicate trends elsewhere.

Protection in Canada

There are no federal, provincial or municipal laws or regulations specifically affecting *Bufo w. fowleri* in Canada. Many populations may be afforded some protection because they are within the boundaries of provincial parks, wildlife reserves or privately held lands with controlled access. Long Point is administered by many authorities at present, including the Canadian Wildlife Service (in three sections), Ontario Ministry of Natural Resources (including Long Point Provincial Park in two sections), the Long Point Company, and the Canadian Ministry of Transport (G. McKeating. 1983. Management plan: Long Point National Wildlife Area. Canadian Wildlife Service unpublished report, 72 pages). Except for a region of private cottages and the provincial park at the neck of the point, and some private holdings on the point itself, there is little development at Long Point and most of the land and marsh is in conservation areas. The Long Point Company's principle objective is the maintenance of duck populations and duck habitats for fall hunting by its members (Heffernan and Nelson 1979). The adjacent Big Creek area is also largely a National Wildlife Area administered by the Canadian Wildlife Service (G. McKeating and K. Dewey. 1984. Management plan: Big Creek National Wildlife Area, Canadian Wildlife Service unpublished report, 80 pages). Turkey Point is occupied by the Turkey Point Company and by Turkey Point Provincial Park at its base. Point Pelee (where Fowler's Toads have disappeared) is a national park. Rondeau and Rock Point are provincial parks. Collection without a permit is prohibited in the parks. Other localities for *B. w. fowleri* are unprotected.

Evaluation: Fowler's Toad in Canada

The presence of steep bluffs along much of the Lake Erie coastline limits areas where there may be suitable breeding sites or foraging habitats available. Evident population declines appear to be at Point Pelee and Rondeau Park. These may be due to habitat disturbance or eradication of breeding sites due to development of these sites as high-use parks, thus attracting considerable numbers of people.

As all known breeding sites of *B. w. fowleri* in Ontario are in bodies of water continuous with, or adjacent to, Lake Erie they are subject to the impact of fluctuating lake levels. Lake Erie has risen and fallen considerably during the past 60 years (W. S. W. Bradstreet. 1977. The biological environment of Long Point, Lake Erie: An overview. Unpublished report to the Nature Conservancy of Canada. 159 pages). In 1985, Lake Erie was unusually high and I observed toads singing from sites much closer to the road at Long Point than I had in 1977 through 1981 when lake levels were much lower. It is probable that occasional extremely low water levels may also cause changes in the movement patterns and calling sites of toads. Winter storms on Lake Erie may cause inundation and freezing of portions of the lake shore or may wash away or destroy some beach areas (Bradstreet 1977, *unpublished,* cited above), as happened during the winter of 1984-1985. This may result in mortality among hibernating toads or other anurans. Schueler (1981) noted fluctuations in numbers of Leopard Frogs (*Rana pipiens*) at Long Point, although these frogs are aquatic hibernators unlike the toads. However, the building of breakwalls along Lake Erie to protect beach front properties from high lake levels may have drastic effects on critical beach habits.

The use of chemicals in agriculture may have contributed to the declines in toad populations in southwestern Ontario. Point Pelee and Pelee Island, especially, have been subject to intensive agricultural activity since World War II. Lazell (1976) attributed the decline in populations of Fowler's Toads on Cape Cod to pesticide use. Sanders (1970) found tadpoles of *B. w. fowleri* to be highly susceptible to the herbicide Trifluralin and the insecticide Endrin in particular. For five-week-old tadpoles, Sanders (1970) calculated an LT_{50} at 96 hrs exposure (50% of tadpoles dead) at 0.10 ppm and 0.12 ppm for these two compounds, respectively. By comparison, the comparable figure for DDT was 1.0 ppm. Tadpoles grew more susceptible as they grew older. At seven weeks, approaching metamorphic climax, Sanders (1970) calculated an LT_{50} of only 0.03 ppm for DDT. Adults are equally susceptible to poisoning by these chemicals (Ferguson and Gilbert 1968; Sanders 1970). C. A. Campbell (1975. Reproduction and ecology of turtles and other reptiles and amphibians of lakes Erie and St. Clair in relation to toxic chemicals. Unpublished report to Canadian Wildlife Service) reported significant, sublethal levels of toxic chemicals accumulated in specimens of *B. w. fowleri* from Ontario.

Crtical habitat for *B. w. fowleri* in Canada does not appear to be suffering increased destruction from human intervention at this time. Most such land is too sandy to be suitable for farming. There is a large industrial plant at Port Maitland close to a breeding site used by *B. w. fowleri*, but the plant does not appear to threaten the critical toad habitats. The industrial development at Nanticoke does not appear to be situated directly at or near present populations of *B. w. fowleri.* In the main, most *B. w. fowleri* habitat is either under the jurisdiction of provincial or federal parks or reserves or controlled by private concerns that do not appear, at present, to be actively considering industrial or residential developments (*see* G. McKeating 1983 and G. McKeating and K. Dewey 1984, *unpublished,* full citations in Protection section). Some habitats have been built upon with cottages, not always with greatly apparent detrimental effects on the toads, as at Point Abino.

The populations of *B. w. fowleri* in Canada are in effect, a northern island population with respect to the rest of their species, separated from them by Lake Erie. Although locally abundant at some locations, the restricted range in Canada is sufficient to justify the COSEWIC designation Rare (*see* Cook and Muir 1984). [Revised to Vulnerable by COSEWIC in April 1990.]

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Addendum

The Ontario Herpetofaunal Summary series (Oldham, 1988; Oldham and Sutherland, 1986; Oldham and Weller, 1989; Weller and Oldham, 1988) includes 70 additional reports of Fowler's Toads in Ontario for 1984-1986, largely from Long Point, Rondeau and vicinities. Further, Weller and Oldham (1988) map all records up to and including 1988, although no documentation is provided for 1987 and 1988. Some of the records cited by Oldham (1988) for Haldimand-Norfolk Regional Municipality are obtained from Gartshore (1987), who reports two specimens, one from Jarvis (NMC 32725) and one, an "apparent hybrid", from near Varency Woods (NMC 29569). Both sites are well inland from Lake Erie. F.R. Cook and I have examined these specimens and they are both American Toads. There is thus no evidence of Fowler's Toads occurring significantly inland from Lake Erie in Ontario. An additional specimen listed by Gartshore (1987) from the Courtright Ridge of Long Point in Lake Erie (NMC 29565) is also *B. americanus* but this locality has a large population of Fowler's Toads as well.

An important additional reference to the biology of a northern population of *B. w. fowleri* is Breden (1988).

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Additions to the Bryophyte Flora of Alberta, Saskatchewan, and Manitoba

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Johnson, J. D. 1989. Additions to the bryophyte flora of Alberta, Saskatchewan, and Manitoba. Canadian Field-Naturalist 103(4): 497–508.

An ecological study of peatlands in the boreal forest of west-central Canada adds one hepatic to the known bryophyte flora of Alberta, 18 hepatics and 17 mosses to the flora of Saskatchewan, and 11 hepatics and 9 mosses to the flora of Manitoba.

Key Words: Alberta, Saskatchewan, Manitoba, new records, bryophytes, boreal forest.

Canada's prairie provinces possess enormous areas of peat. The most recent estimates show that about 20% of the land area of Alberta, 16% of Saskatchewan, and 38% of Manitoba is covered with peat (Tarnocai 1985). The resources involved are considerable, whether viewed from the agricultural, forestry, horticultural, or energy perspective. Any development plans for the use of these resources must be based on an understanding of peatland ecology to determine the suitability of various kinds of peatlands for different uses and the possibilities for rehabilitation of exploited areas. The present state of knowledge of peatland development in the western region is very incomplete, and all available information is confined to a few local areas.

A study of peatland dynamics is in progress within the Boreal Wetland Regions of Alberta, Saskatchewan, and Manitoba. This study characterizes the various peatland types in terms of vegetation, both past and present, and chemistry of surface and subsurface peat deposits, quantifying and characterizing the peat occurring in various peatland forms. The information gathered will be used to characterize the dynamics of various peatland forms in the Boreal Wetland Regions. This paper presents some results from the vegetation sampling conducted to characterize the various peatland types.

In comparison to the bryophyte flora of many other regions of Canada, that of Saskatchewan and Manitoba is poorly known. One only has to look at the *Checklist of the mosses of Canada II* (Ireland et al. 1987) and this immediately becomes evident. Alberta, on the other hand, has been comparatively well studied, primarily through the work of C. D. Bird (Bird 1973; Bird and Hong 1975) and D. H. Vitt (Vitt 1977; Vitt and Andrus 1977), and new finds are less likely.

The present study of peatlands in the boreal forest regions of Alberta, Saskatchewan, and Manitoba resulted in a number of interesting bryophyte collections, including a number of species previously unreported from these provinces. New species were ascertained through a survey of various checklists (Bird 1973; Ireland et al. 1987; Vitt 1977), other publications (Harms 1978; Janssens 1983a, b; Longton 1981; Parker 1982), and a number of herbaria (ALTA, CAFB, CANM, MMMN, SASK, UAC, and WIN).

This paper adds one hepatic species to the known bryophyte flora of Alberta, 18 hepatic and 17 moss species to the known flora of Saskatchewan, and 11 hepatic and 9 moss species to the known flora of Manitoba. Including these reports and a survey of the above-noted sources, the Alberta flora now stands at 136 species of hepatics, the Saskatchewan flora at 39 species of hepatics and 268 species of mosses, and the Manitoba flora at 70 species of hepatics and 331 species of mosses. Further research will undoubtedly add to these totals, particularly those for Saskatchewan. Nomenclature follows Stotler and Crandall-Stotler (1977) for the hepatics, and Ireland et al. (1987) for the mosses.

Vegetation

A total of 255 peatland sites were investigated in detail during this study. A number of incidental observations were also made in other habitats (mostly rock outcrops). The peatlands fall into three major groups: fens, bogs, and swamps, as defined by Zoltai et al. (1973). These groups were further subdivided on the basis of physiognomy. The fens were classified into five groups: treed, shrubby, sedge, ribbed, and poor. Treed fens are dominated by Larch, *Larix laricina* (with or without Black Spruce, *Picea mariana*); shrub fens by the birch *Betula pumila* and/or low-growing species of willow, *Salix*; and sedge fens by species of sedge, *Carex*. Ribbed fens have a surface pattern of elevated ridges dominated by *Larix* and/or

Betula and depressions dominated by *Carex* and members of the Amblystegiaceae. In comparison with other types of fens, poor fens are nutrient poor. They are open and usually sedge dominated, but they have a conspicuous cover of *Sphagnum* as opposed to the brown mosses (Amblystegiaceae) in most sedge fens. The bogs studied fall into two main groups: those with trees (*Picea mariana*) and those without trees (open bogs); the latter was rare in the area studied. The bogs with trees were separated into two types based on vegetation composition: wooded bogs and treed bogs. Wooded bogs have a scattered cover of *Picea mariana*, often less than 5 m in height, and a ground cover dominated by *Sphagnum (S. fuscum, S. magellanicum*, and *S. angustifolium*). Treed bogs have a denser and taller (over 5 m) cover of *Picea mariana* and a ground cover with a higher proportion of feather mosses (predominantly *Pleurozium schreberi*). The swamps examined during the field study included three basic types: those dominated by *Picea mariana, Thuja occidentalis* (White Cedar) (southeastern Manitoba only), or tall *Salix* spp.

Investigated Sites

Table 1 lists the locations of the peatland and incidental observation sites where bryophyte species new to the area were found. The sites have been broken down by province and numbered consecutively from south to north. Some nearby sites have been lumped together and given a common number. The investigated sites are indicated in Figure 1. The numbers that follow the species in the annotated list are those of the sample sites, and numbers in brackets are voucher numbers. All voucher specimens are those of the author, except as noted. Voucher specimens are deposited in the herbarium of the Northern Forestry Centre in Edmonton (CAFB).

Annotated Records

HEPATICAE

Aneura pinguis (L.) Dum. Saskatchewan: 2, 4, 23, 26 (7428), 27, 33b, 38, 41, 43a, 44, 47, 54 (7429), 55a (6547). This very widespread species occurred in rich fens, usually in strands intermixed with *Scorpidium scorpioides, Drepanocladus revolvens, Calliergon trifarium*, or sometimes *Campylium stellatum*. Across its range it is a species of wet banks and humus along streams and in swamps (Conard and Redfearn 1979).

Barbilophozia hatcheri (Evans) Loeske. Saskatchewan: 56 (6548), 57 (6549). This is a species with an essentially subarctic-subalpine to arctic-alpine distribution found on rocks, soil, or logs across northern North America south to California, Colorado, Minnesota, Michigan, and New England (Schuster 1969).

Barbilophozia kunzeana (Hüb.) Gams. Saskatchewan: 49 (7451). This species is generally distributed across northern North America south to British Columbia, Colorado, Minnesota, Michigan, and New England (Schuster 1969) in a fairly diverse range of habitats. These include marshes, stream margins, wet rocks, rock crevices, amongst *Sphagnum* or other bryophytes, or occasionally on rotten wood (Schuster 1969). Its occurrence in Saskatchewan fills a gap between Alberta and Manitoba records.

Calypogeja sphagnicola (H. Arnell et J. Perss.) Warnst. et Loeske. Manitoba: 69, 75 (6243), 76, 79b (6242), 82, 85, 86 (6244), 87, 89, 90 (6245), 95 (5124), 96 (5123), 110b (5125), 112, 113. As the name suggests, this species was almost invariably found growing over or amongst *Sphagnum* spp., either living or dead, very rarely with other bryophytes. It was actually quite common throughout the study area, as might be expected in a study of peatlands where *Sphagnum* spp. are often dominant constituents. However, the species usually occurred only as scattered strands amongst the peat moss, and good collections were hard to obtain. The species' distribution includes Alaska, the Yukon, British Columbia, Alberta, Saskatchewan, Ontario, Quebec, Minnesota, and the eastern United States (Schuster 1969). The Manitoba localities help to broaden a spotty distribution picture for the species in western North America.

Cephalozia catenulata (Hüb.) Lindb. Manitoba: 76b (6237) — mixed with *Barbilophozia lycopodioides*. This species occurs on rotten wood and peaty soil, or occasionally on sandstone, from British Columbia to Quebec and Newfoundland south to California, Minnesota, Kansas, and the Gulf States (Conard and Redfearn 1979). It was rare at the above site; only a few scattered strands were located amongst the larger collection of *Barbilophozia*. The occurrence of this species in southeastern Manitoba fills part of a gap in the distribution northward from Minnesota and westward from Ontario.

Cephalozia connivens (Dicks) Lind. Saskatchewan: 8, 22b (7453), 36 (7454), 41, 51 (7456), 54 (7457). Manitoba: 69 (6246), 70 (6247), 74 (6249), 75, 75a, 77 (6248), 79a, 79b, 84 (6250), 86, 89, 90 (6251), 91, 93, 96, 97, 100 (5126), 108 (5127), 113 (5128). *Cephalozia connivens* occurred with regularity as thin strands mixed with other more conspicuous bryophytes on wet peaty soil, amongst *Sphagnum* spp., or occasionally on rotting wood. Its distribution is from Alaska to Quebec, Labrador and Newfoundland south to British Columbia, Minnesota, Kansas, Missouri, Texas, and the Gulf States (Conard and Redfearn 1979). It was the most abundant of the *Cephalozia* spp. encountered during the study.

TABLE 1. Sample sites

Site No.	Location	Latitude N	Longitude W	Habitat
	Alberta			
1	10 km N of Kimiwan L.	55° 53′	116° 55′	wooded bog
	Saskatchewan			
2	Hwy. 3, 19 km W of Hudson Bay	52° 51′	102° 40′	sedge fen
3	2° Road 691, 12.5 km N of Snowden	53° 36′	104° 39′	treed bog
4	S of Torch R., 12.5 km ESE of Candle L.	53° 44′	105° 04′	ribbed fen
5	W side of Candle L.	53° 51′	105° 27′	treed fen
6	Hanson L. Road, 5 km N of White Gull Cr.	53° 54′	104° 39′	treed fen
7	White Swan Road, W of White Gull L.	53° 55′	105° 08′	shrub fen
8	2° Road 264, 2 km E of Pr. Albert N.P.	53° 56′	105° 58′	wooded bog
9	Third Meridian L., Pr. Albert N.P.	53° 56′	106° 00′	treed fen
10	White Gull Cr., 13 km NE of White Gull L.	53° 58′	104° 52′	wooded bog
11	Nikik L.	54° 00′	105° 52′	ribbed fen
12	1.5 km S of Fairy Glen L.	54° 04′	104° 45′	sedge fen
13	White Swan Road, 2 km N of Lorens L.	54° 05′	105° 00′	shrub fen
14	White Swan Road, E of White Swan Lakes	54° 09′	104° 59′	treed fen
15	Camp 10 Road, 2.5 km W of Hwy. 2	54° 15′	105° 58′	shrub fen
16	Hwy. 55, 4.5 km SW of Green L.	54° 16′	107° 51′	wooded bog
17	2° Road 969, E side of Montreal L.	54° 17′	105° 31′	shrub fen
18	2° Road 969, E side of Montreal L.	54° 25′	105° 31′	shrub fen
19	Clarke L. Road	54° 25′	107° 07′	wooded bog
20	Lac des Isles	54° 26′	109° 25′	shallow water
21	Weyakwin L. Road, 5 km W of Hwy. 2	54° 27′	105° 54′	treed fen
22 a,b	Hwy. 167, N of Meridian Cr.	54° 32′	102° 07′	a) limestone cliff b) treed fen
23	Doré L. Road, 9 km SE of Doré L.	54° 35′	107° 18′	ribbed fen
24	Hwy. 165, 7.5 km E of Wuchewun R.	54° 39′	104° 38′	treed fen
25	Hwy. 155, 2 km N of Waterhen R.	54° 40′	107° 49′	wooded bog
26	E of Ballantyne Bay, Deschambault L.	54° 41′	103° 18′	sedge fen
27	W of Bertrum Bay, Hanson L.	54° 42′	102° 54′	treed fen
28	Hwy. 155, 6.5 km N of Waterhen R.	54° 42′	107° 49′	wooded bog
29	2° Road 969, 14 km S of jct. with Hwy. 165	54° 43′	105° 28′	wooded bog
30 a,b	Hwy. 165, 4.5 km W of Nipekamew R.	54° 45′	105° 03′	a) treed fen b) sedge fen
31	Hwy. 165, 1 km E of Reilander Cr.	54° 46′	105° 05′	shrub fen
32	2° Road 969, 6 km S of jct. with Hwy. 165	54° 46′	105° 23′	treed fen
33 a,b	Wapawekka L. Road	54° 48′	104° 48′	a) wooded bog b) treed fen
34	Hanson L. Road near McBride L.	54° 49′	102° 46′	wooded bog
35	Highway Cr., W of Hwy. 2	54° 49′	105° 33′	wooded bog
36	Hanson L. Road, W. of Johnson L.	54° 52′	102° 24′	treed fen
37	Hanson L. Road, E of Tyrrell L.	54° 53′	102° 05′	wooded bog
38	Hwy. 135, E of Doupe Bay, Jan L.	54° 53′	102° 45′	treed fen
39	Giles Cr., N side of Wapawekka L.	54° 59′	104° 45′	sedge fen
40	W of Hwy. 2, 5 km SW of La Ronge	55° 04′	105° 20′	treed fen
41	Hwy. 135, 8 km S of Pelican Narrows	55° 07′	102° 52′	treed fen
42	2° Road 965, NE of Hazle L.	55° 08′	108° 00′	treed fen
43 a,b	W of Hwy. 102, 9 km NNW of La Ronge	55° 11′	105° 21′	a) ribbed fen b) wooded bog
44	Hwy. 102 near Waden Bay, Lac la Ronge	55° 15′	105° 13′	sedge fen
45	Hwy. 155, 9 km SE of Canoe R.	55° 18′	107° 51′	poor fen
46	Hwy. 102, S of MacKay L.	55° 26′	104° 56′	open bog
47	W of Rosser Bay, Lac Île-à-la Crosse	55° 30′	108° 04′	ribbed fen
48	Hwy. 102, 58 km NE of La Ronge	55° 32′	104° 48′	wooded bog
49	Hwy. 155, 38 km SE of Buffalo Narrows	55° 35′	108° 09′	treed fen
50	W of MacBeth Channel, Churchill R.	55° 42′	108° 16′	poor fen
51	2° Road 925, S of Little Point L.	55° 47′	108° 49′	wooded bog
52	Hwy. 155, 5.5 km SE of Buffalo Narrows	55° 49′	108° 27′	wooded bog
53	Hwy. 155, 2 km SE of Buffalo Narrows	55° 50′	108° 28′	treed bog

TABLE 1. *Continued.*

Site No.	Location	Latitude N	Longitude W	Habitat
54	8 km NW of Buffalo Narrows	55° 54′	108° 35′	shrub fen
55 a,b	Gunnar Mines, Lake Athabasca	59° 23′	108° 54′	a) wet mine tailings b) granite rock outcrop
56	Gunnar Mines, Lake Athabasca	59° 24′	108° 53′	granite rock outcrop
57	Langley Bay, Lake Athabasca	59° 24′	108° 53′	granite rock outcrop
58	Nero L., 8 km SW of Uranium City	59° 31′	108° 41′	granite rock outcrop
	Manitoba			
59	4 km SW of Piney	49° 03′	96° 00′	shrub fen
60	3 km NE of Whitemouth L.	49° 17′	95° 35′	drowned bog
61 a,b	Prov. Road 308, 21 km N of Moose L.	49° 24′	95° 22′	a) poor fen b) sedge fen
62	19 km NNE of Whitemouth L.	49° 25′	95° 33′	ribbed fen
63	Prov. Road 308, 23 km NNW of Moose L.	49° 26′	95° 24′	poor fen
64	Prov. Road 308, 26 km NNW of Moose L.	49° 26′	95° 27′	ribbed fen
65	4 km NNE of Hugo L.	49° 34′	96° 14′	white cedar swamp
66 a,b	6 km NE of Giroux	49° 36′	96° 30′	a) ribbed fen b) treed fen
67	3.5 km E of East Braintree	49° 40′	95° 34′	treed fen
68	Hwy. 44, 19 km ESE of Rennie	49° 49′	95° 18′	treed fen
69	Hwy. 44, 7 km W of Rennie	49° 52′	95° 38′	wooded bog
70	Hwy. 44, 10 km E of Seddon's Corner	50° 05′	96° 09′	wooded bog
71	8 km E of Seven Sisters Falls	50° 06′	95° 54′	treed bog
72	Near Heart L., Whiteshell Prov. Park	50° 07′	95° 40′	willow swamp
73	Prov. Road 214, 8 km N of Seddon's Corner	50° 08′	96° 17′	coniferous swamp
74	Prov. Road 317, 17 km W of Lac du Bonnet	50° 16′	96° 18′	treed fen
75	Prov. Road 317, 14 km W of Lac du Bonnet	50° 17′	96° 16′	treed bog
76 a,b	Prov. Road 313, 2 km WNW of Pointe du Bois	50° 18′	95° 35′	a) wooded bog b) granite rock outcrop
77	Prov. Road 304, 2 km W of Stead	50° 26′	96° 28′	treed bog
78	Bird R., 2.5 km NW of Bernic L. mine	50° 27′	95° 28′	granite rock outcrop
79 a,b	Hwy. 59, 3 km E of Beaconia	50° 27′	96° 31′	a) treed bog b) coniferous swamp
80	Prov. Road 304, 10 km NE of Stead	50° 29′	96° 20′	shrub fen
81	Near Bead Lakes, Riding Mtn. N.P.	50° 47′	99° 59′	sedge fen
82	Prov. Road 233, 3.4 km E of Washow Bay	51° 07′	96° 57′	wooded bog
83	Prov. Road 233, 3.5 km W of Washow Bay	51° 07′	97° 03′	sedge fen
84	Prov. Road 234, 3 km N of Beaver Cr.	51° 25′	96° 53′	wooded bog
85	1 km W of Beautiful L., Duck Mtn. Prov. Park	51° 33′	101° 01′	treed fen
86	1.5 km NE of Singush L., Duck Mtn. Prov. Park	51° 38′	100° 46′	treed fen
87	Prov. Road 234, 8 km NW of Pine Dock	51° 42′	96° 52′	wooded bog
88	Duck Mtn. Prov. Park	51° 48′	100° 54′	wooded bog
89	N of Roaring R., Duck Mtn. Prov. Park	51° 54′	100° 59′	treed fen
90	8.5 km E of Harte Mtn., Porcupine Prov. For.	52° 28′	101° 18′	wooded bog
91	6.5 km E of Harte Mtn., Porcupine Prov. For.	52° 28′	101° 20′	wooded bog
92	1.5 km E of Bell L., Porcupine Prov. For.	52° 31′	101° 12′	wooded bog

TABLE 1. *Concluded.*

Site No.	Location	Latitude N	Longitude W	Habitat
93	3 km E of North Steeprock L.	52° 35′	101° 18′	treed fen
94	Near Katimik L., 30 km S of Grand Rapids	52° 55′	99° 18′	white cedar swamp
95	Whitefish Point, Lake Winnipegosis	52° 58′	101° 00′	shrub fen
96	Swamp Cr., 76 km SE of The Pas	53° 12′	100° 39′	treed fen
97	Overflowing R., 61 km S of The Pas	53° 17′	101° 15′	ribbed fen
98	Hwy. 10, 43 km S of The Pas	53° 27′	101° 20′	ribbed fen
99	W of Hwy. 10, 44 km SSW of The Pas	53° 28′	101° 31′	ribbed fen
100	NE of Culdesac L., 38 km SW of The Pas	53° 38′	101° 43′	treed fen
101	Driftwood L., 51 km ESE of The Pas	53° 45′	100° 28′	shrub fen
102	Minago R., Hwy. 6	54° 12′	99° 10′	shallow water
103	Hwy. 6, 9.5 km N of Minago R.	54° 16′	99° 08′	shrub fen
104	Cormorant L., 50 km NE of The Pas	54° 17′	101° 02′	treed fen
105	Namew L., 42 km SW of Cranberry Portage	54° 17′	101° 47′	wooded bog
106	Hwy. 10, 20 km S of Cranberry Portage	54° 25′	101° 22′	treed bog
107	Hwy. 6, 9 km N of Hargrave R.	54° 28′	99° 03′	ribbed fen
108	Hwy. 10, 12.5 km S of Cranberry Portage	54° 28′	101° 22′	treed bog
109	Prov. Road 391, S of Simonhouse L.	54° 31′	101° 06′	sedge fen
110 a,b	Hwy. 10, 9 km S of Cranberry Portage	54° 31′	101° 22′	a) treed bog b) sedge fen
111	Prov. Road 391, 10 km N of Wekusko	54° 35′	99° 47′	ribbed fen
112	Hwy. 6, 9 km S of Ponton	54° 36′	99° 06′	wooded bog
113	Prov. Road 391, 18 km WSW of Ponton	54° 36′	99° 25′	wooded bog
114	Prov. Road 391, 14 km WSW of Ponton	54° 38′	99° 21′	shrub fen
115	Hwy. 10, 4 km W of Mistik Cr.	54° 39′	101° 33′	wooded bog
116	Prov. Road 392, 5.5 km S of Wekusko Falls	54° 44′	99° 58′	treed fen
117	Kississing L. Road, 24 km ENE of Flin Flon	54° 48′	101° 29′	open bog
118	Chisel L. Road, 3 km W of Snow L.	54° 52′	100° 04′	treed fen
119	Kississing L. Road, 28 km NE of Flin Flon	54° 53′	101° 27′	wooded bog
120	Setting L., 4 km NW of Wabowden	54° 56′	98° 41′	granite rock outcrop
121	Kississing L. Road, 33 km NE of Flin Flon	55° 05′	101° 36′	treed fen

Cephalozia lunulifolia (Dum.) Dum. Saskatchewan: 21 (7459), 33a (R. L. Longworth *s.n.*), 35 (R. L. Longworth *s.n.*), 37 (7458), 48. Manitoba: 87 (6252), 92 (6253), 96 (5129), 97 (5130), 107 (5132), 110b, 115 (5131). *Cephalozia lunulifolia* is found on peaty soil, amongst *Sphagnum* spp. or other mosses, on moist rocks, soil banks, or rarely on rotten wood (Conard and Redfearn 1979). Its wide distribution is from Alaska to Newfoundland and Nova Scotia, south to California, Nevada, Wyoming, Kansas, Missouri, Illinois, Indiana, Georgia and Florida (Conard and Redfearn 1979).

Cephalozia pleniceps (Aust.) Lindb. Saskatchewan: 10 (7460), 19 (7461), 32 (R. L. Longworth *s. n.*), 47 (7462), 52. Manitoba: 104 (5133), 105. This species was widespread but not nearly as common as the former two species. It occurred on peaty soil and amongst *Sphagnum* spp. It has a widespread distribution tending toward arctic-alpine (Frye and Clark 1937). In the north it is known from Alaska to Greenland south to British Columbia, Alberta, Quebec, and Nova Scotia. In the United States it occurs from Washington to California and New Mexico and from Wyoming and Montana east to the New England states (Frye and Clark 1937).

Cephaloziella hampeana (Nees) Schiffn. Manitoba: 82 (6254). Found on moist sandy or peaty soil or with *Sphagnum* spp., this species occurs from British Columbia to Nova Scotia south to California, Wyoming, Minnesota, Missouri, Michigan, New York, and Massachusetts (Conard and Redfearn 1979). The distribution of this species in western North America was recently mapped by Hong (1986).

Cladopodiella fluitans (Nees) Joerg. Saskatchewan: 28, 29 (R. L. Longworth *s.n.*), 30a (R. L. Longworth *s.n.*), 32, 33b, 42, 43b (R. L. Longworth *s.n.*), 46, 50 (7435). Manitoba: (Additional sites to that cited by Longton (1981).) 61a (6255), 117 (5134), 119 (5135). This species is of sporadic occurrence in the area, almost always being found creeping over or amongst *Sphagnum* spp. in generally boggy habitats. Its distribution is from British Columbia and Washington east to Quebec, Newfoundland, and Nova Scotia south to Minnesota, Michigan, West Virginia, and New Jersey (Conard and Redfearn 1979). When found, this species can sometimes be abundant.

Geocalyx graveolens (Schrad.) Nees. Manitoba: E. of Moose L. — coniferous swamp (D. Mueller-Dombois 131-1), 71 (6257), 85 (6258), 97 (5136), 105 (5137), 120 (5138). This species was actually somewhat more common in the area than the cited collections would indicate. It often occurred elsewhere in shaded situations as a few scattered strands mixed in with other bryophytes on peaty soil or rarely rotten wood. This is the typical habitat for the species (Conard and Redfearn 1979). Its general distribution is from Alaska to Quebec and New Brunswick south to California, Idaho, the Ozarks, Tennessee, and North Carolina (Conard and Redfearn 1979).

Jungermannia leiantha Grolle. Manitoba: 77 (6285). This species has a transcontinental distribution in the taiga of North America, but with a large gap in its range in the region west of Minnesota (Schuster 1969). In the west it is known from southern Alaska, south to California, and east to Montana, Idaho and Utah. In the east it occurs from Ontario to Newfoundland and south as far as Georgia (Schuster 1969). Its normal habitats include damp, shaded rocks, sandy banks, soil-covered rocks near streams, peaty ground in boggy areas, or over moist, decaying logs (Schuster 1969). The present collection comes from dead *Sphagnum* in a treed bog. The occurrence in southeastern Manitoba extends the distribution northward from Minnesota and westward from Ontario.

Lophocolea minor Nees. Saskatchewan: 5 (7469), 15 (7438), 18 (7470), 38 (7468). This species was not common and appeared to favor the more minerotrophic peatland sites as the collection locations indicate. The diversity of habitats for this species includes shaded rocks, banks of streams, bases of trees and rotten logs (Conard and Redfearn 1979). The latter was the frequent substratum for the cited collections. The species' distribution is from the Yukon to Ontario south to British Columbia and Colorado and east to Arkansas, Illinois, Pennsylvania, and Virginia (Conard and Redfearn 1979).

Lophozia excisa (Dicks.) Dum. Saskatchewan: 21 (7471), 40 (R. L. Longworth *s.n.*). Although many species in the genus *Lophozia* were encountered during the course of this study, few were particularly abundant. *Lophozia excisa* occurred in fens, but it is reportedly widespread on acid soils, rocks, and humus across northern North America south to California, Wyoming, Minnesota, Wisconsin, Tennessee, and North Carolina (Schuster 1969).

Lophozia grandiretis (Lindb.) Schiffn. Saskatchewan: 6 (7472). This species occurs on damp soil in calcareous habitats (Schuster 1969). It is not particularly widespread in North America. It is known from the Yukon, Alberta, Manitoba, Minnesota, and Vermont (Schuster 1969).

Lophozia guttulata (Lindb. et H. Arnell) Evans. Saskatchewan: 24 (R. L. Longworth *s.n.*). Rotting wood and peaty soil are the usual substrata for this species (Schuster 1969). It is distributed across northern North America and south to California, Utah, Colorado, Minnesota, Wisconsin, Michigan, New York, and Connecticut (Schuster 1969).

Odontoschisma denudatum (Nees *ex* Mart.) Dum. Alberta: 1 (7581). Saskatchewan: 10 (7443). Manitoba: 84 (6286), 115 (5168). All cited collections of this species were on *Sphagnum*. Throughout its range it is known to occur on rotting wood and shaded acid rocks (Conard and Redfearn 1979). The occurrence on *Sphagnum* is somewhat atypical. The species is found in the eastern half of North America, from Minnesota to Quebec, Newfoundland and Nova Scotia south to the Gulf States (Conard and Redfearn 1979). The cited collections extend the distribution of this species considerably west and north from Ontario and Minnesota.

Riccardia multifida (L.) S. Gray. Saskatchewan: 14 (7477), 17, 24, 25, 32, 33a, 34. Manitoba: 74, 75, 82, 89 (6295), 93, 97 (5181), 106 (5182). As is the case with a number of other species in this listing, this small thalloid liverwort occurred frequently as an admixture with other bryophytes. The species never formed large patches, normally being found as scattered strands on wet soil or rotting wood in the more mineral-rich peaty habitats. It is also known to inhabit wet rocks (Conard and Redfearn 1979). It is extremely widespread in North America (Conard and Redfearn 1979).

Scapania curta (Mart.) Dum. Saskatchewan: 57 (6552) — mixed with *Cnestrum alpestre* and *Pohlia cruda*. This species occurs on peaty soil, soil-covered rocks, humus or rotten wood, often among other bryophytes (Frye and Clark 1937), as is the case with the cited collection. It is found from Alaska to Newfoundland south to California, Colorado, Minnesota, Wisconsin, Michigan, and New York (Conard and Redfearn 1979).

Scapania irrigua (Nees) Gott. et al. Saskatchewan: 15 (7478), 24 (R. L. Longworth *s.n.*). Humus, clayey soil and rotten wood in wet habitats are the usual locations in which to find this species (Frye and Clark 1937). The cited collections are on peat. The species occurs from Alaska to Newfoundland

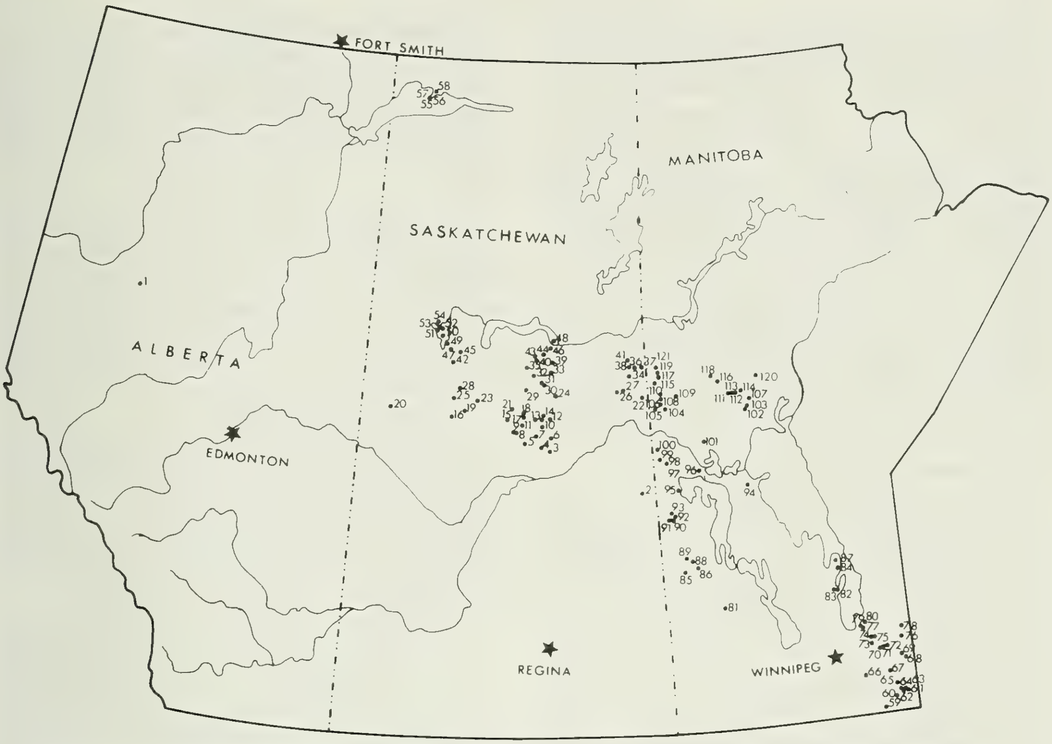

FIGURE 1. Sites investigated in the study area. Locations, coordinates, and habitat are given in Table 1.

south to California, Minnesota, Pennsylvania, and New Jersey (Conard and Redfearn 1979).

Scapania paludosa (K. Müll.) K. Müll. Saskatchewan: 23 (7480), 28 (7479), 33b (R. L. Longworth *s.n.*). Manitoba: 68 (6296). This species was surprisingly abundant at the Doré Lake site, forming an extensive carpet of several square metres in one location, almost to the exclusion of other bryophytes. Otherwise, it is normally found in small clumps or mixed with other bryophytes in fairly mineral-rich sites such as swamps, springs, or rivulets (Frye and Clark 1937). It can often be wholly or partly submerged and has an arctic-alpine distribution, being reported from Alaska and the Yukon south to Oregon, east to Montana, Alberta, Michigan, Quebec, and New England (Frye and Clark 1937).

Scapania undulata (L.) Dum. Saskatchewan: 55a (6551). This is an exceedingly polymorphic species growing in a wide range of habitats from aquatic to dry sites (Conard and Redfearn 1979). It is as likely to be found in rivulets or springs as it is on wet earth, stones, or rotten wood (Frye and Clark 1937). Hence, the Saskatchewan collection from mine tailings is not as unusual as it might first appear. *Scapania undulata* is known from Alaska to Newfoundland south to California, Arizona, Colorado, the Ozarks, Tennessee, and Georgia (Conard and Redfearn 1979).

Tritomaria exsectiformis (Breidl.) Loeske. Saskatchewan: 22a (7481). This species grows in small patches on decaying wood, peaty soil, banks and rock faces across northern North America south to California, Utah, Colorado, Minnesota, Wisconsin, Michigan, New York, and Connecticut (Schuster 1969). The Saskatchewan occurrence extends the distribution eastward from Alberta, leaving Manitoba as the only province from which the species has not been reported.

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Brachythecium turgidum (C. J. Hartm.) Kindb. Saskatchewan: 7 (7155), 10 (7156), 13 (7157), 14 (7158), 15 (7159), 39 (R. L. Longworth *s.n.*). Found across much of northern North America, this species is most prevalent in calcareous habitats (Crum and Anderson 1981). In this study it was normally found as an admixture with other species, or in small patches in wet microhabitats in intermediate fens. Most of the collections came from humus over rotting wood in shrubby and treed fens. The species typically occurs on wet soil or rocks near streams, pools or waterfalls (Crum and Anderson 1981). The collection locations in Saskatchewan are fairly close together, but the species did occur mixed with *Drepanocladus* spp. at other locations.

Bryum cyclophyllum (Schwaegr.) B.S.G. Saskatchewan: 49 (7164). This species has a very sporadic distribution in North America and is not common anywhere. In Canada, it has been reported from the Yukon and Northwest Territories, British Columbia, Alberta, Ontario to Nova Scotia, Newfoundland, and Labrador (Ireland et al. 1987). It normally occurs on wet soil (Crum and Anderson 1981). The present collection comes from peat in a Tamarack fen. When found it is usually accidental, as a fragment mixed with other collections, as was the case with the Saskatchewan specimen.

Calliergon trifarium (Web. & Mohr) Kindb. Saskatchewan: 7, 23 (7175), 40 (R. L. Longworth *s.n.*), 47. This species occurs across Canada with the exception of the Maritimes (Ireland et al. 1987). Although widespread, it is not particularly common. It is found in very wet calcareous habitats and is often considered as an indicator species of extremely rich fens. In string fens it often grows completely submerged in flarks with *Scorpidium scorpioides* or at the edges of strings with *Drepanocladus revolvens* or *D. vernicosus* (Crum and Anderson 1981).

Calliergonella cuspidata (Hedw.) Loeske. Manitoba: 64 (6339), 66a (6340), 72 (6341), 80 (6342), 81 (6343), 100 (5216). Considered a calciphile (strongly so in the north, less so southward), this species is found on wet humus in open sedgy places, in wet meadows and swales beside eutrophic lakes, among sedges at the outer edges of pioneering bog mats, and in rich fens (Crum and Anderson 1981). The species has a primarily east-west distribution with a large gap through central North America (Crum and Anderson 1981).

Cnestrum alpestre (Wahlenb.) Nyh. Saskatchewan: 57 (6557) — mixed with *Encalypta procera*. The normal habitats for this calciphilous species include thin soil over rock, ledges or cliffs, and crevices. It is known from Alaska, the Yukon and Northwest Territories, Alberta, and Labrador (Ireland et al. 1987).

Dichelyma falcatum (Hedw.) Myr. Saskatchewan: 20 (W. J. S. Beveridge *s.n.*). Occurring generally across southern Canada, the northern states, and in Alaska, the Yukon, and Labrador, this species is usually encountered attached to rocks in stream beds, in places inundated during part of the year, often in fast-moving water such as rapids (Crum and Anderson 1981).

Dicranella subulata (Hedw.) Schimp. Saskatchewan: 58 (6561). This species has been recorded in all parts of Canada except for Saskatchewan, Manitoba, and the Northwest Territories (Ireland et al. 1987). It prefers moist soil, often in rocky places, in open situations (Crum and Anderson 1981).

Dicranoweisia crispula (Hedw.) Lindb. *ex* Milde. Saskatchewan: 56 (6562). Known to occur generally across Canada, with the exceptions of Saskatchewan, Prince Edward Island, and New Brunswick (Ireland et al. 1987), this species is found on acid rock in moist places, in crevices, or on ledges of cliffs, less commonly on rotting wood (Crum and Anderson 1981).

Dicranum groenlandicum Brid. Saskatchewan: 15 (7185). This species has a distribution similar to that of the foregoing species (Ireland et al. 1987). The present collection is on peat, but the species also occurs on rotting wood. Throughout its range it is predominantly a species of peatlands.

Drepanocladus crassicostatus Janssens. Manitoba: 102 (5326). This species was recently described by Janssens (1983b). It has been found around alkaline lake margins, marshy stream sides, spring ponds and pools in swampy habitats (Janssens 1983b). In either fossil or living form it has been recorded from Alaska, the Yukon Territory, British Columbia, Alberta, Wyoming, and Colorado (Janssens 1983b). This species was also identified from fossil material from site 89 (treed fen bordering small lake). Fossil specimens were identified by Janssens from peat at this site at depths of 150-156 cm and 194-200 cm. Associated species included *Menyanthes trifoliata, Carex limosa, Betula* sp., *Calliergon giganteum, C. trifarium*, and *Sphagnum warnstorfii*. A radiocarbon date of peat taken from this site at a depth of 240 cm below the surface gave an age of 2300 ± 215 years B.P. (S.R.C. sample no. S-2477). From this date a very crude average rate of peat accumulation can be calculated. It is in the range of 10.4 cm/100 yr. On this basis, it can be inferred that *D. crassicostatus* occurred in living form in this area at some time (or times) between very roughly 1925 and 1440 years B.P.

Drepanocladus lapponicus (Norrl.) Smirn. Saskatchewan: 12 (7218), 23 (7209), 43a (R. L. Longworth *s.n.*), 54 (7208). *Drepanocladus lapponicus* is considered a rare species in North America (Janssens 1983a). In fossil or extant form it is known from the Yukon and Northwest Territories, British Columbia, Alberta, Manitoba, the Hudson Bay coast of Quebec, and Minnesota (Ireland et al. 1987; Janssens 1983a). Its habitat includes fens and the edges of lakes and streams (Janssens 1983a). In my collections it is associated with *Calliergon richardsonii, Drepanocladus exannulatus, D. tundrae, D. vernicosus,* and *Scorpidium scorpioides*. This species is not unlike *Scorpidium scorpioides* in aspect. It should be looked for in intermediate and rich fens in the boreal region.

Drepanocladus tundrae (H. Arnell) Loeske. Saskatchewan: 15 (7197), 43a (R. L. Longworth *s.n.*). Manitoba: (Additional sites to that indicated by Janssens (1983a).) 103 (5305), 110b (5301, 5302), 114 (5304), 116 (5305), 118 (5303). Found in rich fens or sometimes submerged in streams, lakes, and pools, this is a circumpolar arctic-alpine species (Janssens 1983a). It occurs primarily in exposed habitats or open *Picea* woodlands, and in North America it has been found in Alaska, the Yukon and Northwest Territories, the mountains of Alberta and British Columbia, the Hudson Bay coast, and Labrador (Janssens 1983a). The species may not have as strong an affinity for coastal and mountainous areas as originally presumed.

Fissidens adianthoides Hedw. Manitoba: 65 (6392), 67 (6393), 73, 74 (6394), 75 (6395), 79b, 83 (6396), 94 (5331), 96 (5329), 99 (5330). This species was encountered more frequently than was *F. osmundoides* (10 vs. 6 sites), a species that has been reported in the literature from northern Manitoba. At two sites the species were found growing together. *Fissidens adianthoides* is known from across Canada with the exceptions of Manitoba and Prince Edward Island (Ireland et al. 1987). It is rare in the Northwest Territories, but becomes more common in eastern North America (Ireland 1982). It grows in a fairly diverse range of habitats including moist soil banks, rotten logs, humus, woody debris, bark at the base of trees, and calcareous or noncalcareous rocks and cliffs beside streams, sometimes even in the spray of waterfalls (Crum and Anderson 1981). The diversity of collection locations would tend to indicate that this species is not too particular about the mineral status of the site, although a slight preference for the more mineral-rich sites is evident. The species would appear to have a scattered distribution in west-central and southeastern Manitoba, but it is not conspicuous by its abundance when found. The nearest records to the Manitoba localities come from Ontario and Minnesota.

Orthotrichum alpestre Hornsch. *ex.* B.S.G. Saskatchewan: 55b (6572). In Canada, this species occurs in the Yukon and Northwest Territories, British Columbia, Alberta, Ontario, Newfoundland, and Labrador (Ireland et al. 1987). It is most often found growing on rock, often in calcareous areas, but not necessarily restricted to such. It is rarely found on trees (Crum and Anderson 1981). The occurrence in northern Saskatchewan places it in a gap between the western Alberta records, the northern records in the Northwest Territories, and the records in Ontario.

Orthotrichum rupestre Schleich. *ex* Schwaegr. Saskatchewan: 56 (6573). This species has a primarily western and northern distribution. In Canada, it has been reported from British Columbia, Alberta, the Yukon and Northwest Territories, Ontario, Newfoundland, and Nova Scotia (Ireland et al. 1987). It is rare in eastern North America (Crum and Anderson 1981). It is almost invariably found growing on noncalcareous rock (Crum and Anderson 1981). The northern Saskatchewan collection extends the distribution north and east from Alberta and north and west from Minnesota and Ontario.

Plagiothecium laetum B.S.G. Saskatchewan: 3 (7269), 9, 16, 17 (7271), 18, 21 (7270), 36, 41, 51, 53 (7272). This species was actually quite common, so the lack of previous records from Saskatchewan is surprising. It was encountered at 10 sites, usually as an admixture with other moss species around the bases of trees. Throughout its range it also grows on rotten logs, stumps, humus and soil on steep banks, and over boulders and cliffs in coniferous woods (Crum and Anderson 1981). It occurs all across Canada with the exception of the high arctic regions, although its primary distribution appears to be east-west (Ireland 1986).

Pohlia elongata Hedw. Manitoba: 78 (6471). The usual habitats of this species include soil over rock ledges, crevices of cliffs, and sometimes over upturned roots in moist shady places, generally preferring acid substrates and coniferous forests (Crum and Anderson 1981). It is a sporadic, but widespread species in a taxonomically difficult group. Its Canadian distribution includes British Columbia, Alberta, Ontario, Quebec, Labrador, Newfoundland, New Brunswick, Nova Scotia, and the Yukon and Northwest Territories (Ireland et al. 1987). The occurrence in Manitoba extends the distribution north and west from Minnesota and Ontario.

Saelania glaucescens (Hedw.) Bomanss. & Broth. Saskatchewan: 57 (6579). This distinctive-looking species is known from all across Canada with the exceptions of Saskatchewan and Prince Edward Island (Ireland et al. 1987), although it is rare in the Maritimes (Ireland 1982). It grows on thin soil on steep banks or bluffs or in rock crevices, generally preferring sheltered situations (Crum and Anderson 1981). The Saskatchewan collection comes from the northwest-facing aspect of the rock outcrop.

Seligeria donniana (Sm.) C. Müll. Saskatchewan: 22a (7286). This tiny moss is known in

Canada from British Columbia, Alberta, Ontario, Quebec, Labrador, Newfoundland, and the Yukon and Northwest Territories (Ireland et al. 1987). It is a species of moist, shaded, calcareous rock (Crum and Anderson 1981). The Saskatchewan collection comes from a moist vertical face of a limestone cliff. Considering its small size, this species is often only encountered by chance and is not likely to be common.

Sphagnum contortum K. F. Schultz. Manitoba: 61b (6507), 62 (6508), 80 (6509), 97 (5436), 98 (5435), 101 (5434), 109 (5438), 116 (5439), 121 (5437). The habitats of *S. contortum* include wet, mineral-rich, usually open, sedgy habitats, often at the edge of bog mats encroaching on more minerotrophic water, meadows, or swales along streams or ponds, drainage ditches, and the "moats" often surrounding raised bogs (Crum and Anderson 1981). It has been found in British Columbia, Alberta, Ontario, Quebec, Nova Scotia, and Newfoundland (Ireland et al. 1987). The occurrence of this species in Manitoba gives its distribution a more transcontinental aspect. Perhaps the only unexpected point to note in this study is the slightly more common occurrence in Manitoba of *S. contortum* compared to *S. subsecundum*. *Sphagnum contortum* was not encountered at any of the Saskatchewan sites examined. It may be present in the area, but if so, only rarely, as in Alberta.

Sphagnum majus (Russ.) C. Jens. Manitoba: 63 (6493), 117 (5448). *Sphagnum majus* is known to occur in all provinces and territories of Canada with the exceptions of Manitoba, Prince Edward Island, and the Yukon (Ireland et al. 1987), but is rare in western North America (Maass 1967). It occurs in pools and wet depressions in open oligotrophic habitats near the coast, but tends towards more minerotrophic habitats inland (Crum and Anderson 1981). It is also found in open drainage channels in sedge mats or in the moat surrounding flat and raised bogs (Crum and Anderson 1981).

Sphagnum papillosum Lindb. Manitoba: 61a (6501). This species is primarily oceanic in distribution. In Canada, it has been found in British Columbia, Ontario, Quebec, Labrador, Newfoundland and the Maritimes (Ireland et al. 1987). It often forms extensive mats in open oligotrophic habitats, frequently at the margin of lakes (Ireland 1982). Inland, it occurs in the relatively mineral-rich parts of poor fens, in the *Larix-Sphagnum* zone bordering pioneering sedge mats, or occasionally in sedgy rich fens (Crum and Anderson 1981). Its occurrence in Manitoba extends the distribution westward from Ontario and northward from Minnesota.

Sphagnum subsecundum Nees *ex* Sturm *sensu stricto*. Saskatchewan: 12 (7308), 13 (7300), 15 (7309), 27, 30b (R. L. Longworth *s.n.*), 31 (R. L. Longworth *s.n.*), 34 (7298), 38 (7307), 41 (7306), 44 (R. L. Longworth *s.n.*), 45 (7310), 46 (R. L. Longworth *s.n.),* 47 (7311). *Sphagnum subsecundum* grows in similar habitats to *S. contortum*, but it has a wider distribution, occurring in all provinces and territories except for Saskatchewan and Prince Edward Island (Ireland et al. 1987). Its general distribution is now transcontinental. Oddly, *S. subsecundum* was encountered only twice in Alberta during this study, but it is known from several locations in the province (Vitt and Andrus 1977).

Splachnum rubrum Hedw. Manitoba: 110a (5484) — on moose dung. Because of their restrictive substrate, the so-called dung mosses are never very abundant, although many have a fairly wide distribution. *Splachnum rubrum* is a rare species, but it has been recorded from across Canada with the exceptions of Manitoba, Newfoundland, Prince Edward Island, the Yukon, and the arctic islands (Ireland et al. 1987). It is usually found on herbivore dung in swampy or boggy types of habitats (Crum and Anderson 1981).

Splachnum vasculosum Hedw. Saskatchewan: 28 (7316). This species is more widespread than the former, but it has not been recorded from Saskatchewan or the Maritimes (Ireland et al. 1987). It is normally found on herbivore dung (Crum and Anderson 1981).

Ulota hutchinsiae (Sm.) Hamm. Manitoba: 76b (6446). This species has a patchy distribution in North America, occurring in Nova Scotia, New Brunswick, Newfoundland, Labrador, Quebec, Ontario, and Minnesota, south to North Carolina (Ireland et al. 1987; Crum and Anderson 1981). It favors acidic rock substrates (Crum and Anderson 1981).

Discussion

The postglacial vegetational history of the study area sheds light on the present distribution of bryophytes by providing a time frame for the availability of suitable habitats. In the geological sense, the boreal forest habitats of the central region are relatively young. The modern boreal forest appears to have achieved its current composition and structure roughly 5-6 × 10^3 B.P. (Ritchie 1976); however, the modern position of the major vegetation zones may not have been attained until roughly 2.5 × 10^3 B.P. (Ritchie 1976). This is comparatively little time for some of the species to have migrated into the area.

Ritchie (1976) has summarized the late-Quaternary vegetational history of the western interior of Canada. Studies indicate that the entire central interior of the continent was occupied by spruce forest from late Wisconsinan time (14-11 × 10^3 B.P.). In the southern portion of the area, an abrupt change from spruce forest to grassland occurred at about 11 × 10^3 B.P. in the southernmost parts, and at 9.5 × 10^3 B.P. at roughly latitude 52° N, in response to a change to a warm, dry climate. North of this latitude, birch woodland, possibly with aspen, preceded the grassland. During this period, few peatlands existed in the semi-arid grasslands, hence habitats suitable for peatland bryophytes were absent. From 6.5-2.5 × 10^3 B.P., there was a gradual spread of the forest southward to replace the grassland in response to a climate with cooler and/or wetter growing seasons. Sites near the modern southern forest boundary show a late development (3 × 10^3 B.P.) of the mixedwood boreal forest from prairie and mixed hardwood deciduous communities. Many peatlands were initiated during this period, and species variability increased as more bryophytes reached the area.

Present bryophyte distribution in the central region suggests that there were different foci from which the species spread into this area. The new distribution records indicate that a number of species with an eastern affinity are present in the area (e.g., *Odontoschisma denudatum* and *Fissidens adianthoides*). The nearest collections to many of the new species cited from Manitoba come from Minnesota and/or Ontario. Further paleobotanical studies in southeastern Manitoba would be of value in elucidating the extent and chronology of the northwestward spread of certain eastern vegetation elements. Other collections help to fill part of the gap between apparent east-west distributions (e.g., *Calypogeja sphagnicola, Scapania paludosa, Calliergonella cuspidata, Plagiothecium laetum, Sphagnum contortum*, and *S. subsecundum*). Further studies may substantiate that this gap is not as pronounced as it appears, as some of these species may be present, but so far uncollected, across the northern part of the central region.

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Effects of Reforestation Upon Small Mammal Communities in New Brunswick

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Parker, G. R. 1989. Effects of reforestation upon small mammal communities in New Brunswick. Canadian Field-Naturalist 103(4): 509–519.

The distribution and characteristics of small mammal communities within conifer plantations in New Brunswick were studied in the summers of 1981 and 1982. Population characteristics were compared to those found in mature conifer and naturally regenerating sites. Eleven species of small mammals were collected from 17 sites. Absolute density, richness and diversity increased immediately following forest harvesting. *Sorex cinereus* (Masked Shrew) and *Clethrionomys gapperi* (Gapper's Red-backed Vole) were the most abundant and ubiquitous species. Small mammal density was lowest within the oldest (15-17 yr) spruce plantations; species diversity was greatest in the youngest spruce plantations and in naturally regenerating clear-cuts. The insectivores (Soricidae) were the primary pioneering trophic group and their numbers declined with age following site disturbance. Grazers (Microtinae) increased in abundance with increases in ground cover values for grasses, sedges and deciduous and conifer foliage.

Key Words: New Brunswick, small mammals, population characteristics, reforestation.

New Brunswick has recently entered into a new era of forest management. As in most eastern provinces, today's forest bears little resemblance to the original Acadian forest. No efforts were made to limit cutting to a level the forest could sustain. The development of the pulp and paper industry in the early 1900s allowed the use of most softwood trees and spawned the proliferation of large clear-cut operations.

Today, the forests are very uneven in age structure and characterized by a preponderance of old and very young trees and few of intermediate age (25-55 yrs). This situation was caused primarily by the development of an even-aged forest following wide-spread mortality from the Spruce Budworm (*Choristoneura fumiferana*) from 1913 to 1919. This forest pest again threatens the same mature forest it helped create 70 years ago (Buchta 1986).

New Brunswick supports the highest percentage of land in forest production of all the provinces and implementation of the Crown Lands and Forest Act in 1982 committed the province to long-term management of its forest resources. A program of timber supply analysis and long-term cutting schedules was designed to shift the age structure of the forests to a more diversified arrangement ensuring higher sustained levels of use.

New Brunswick is also committed to integrating the needs of wildlife into contemporary forest management. A program of forecasting habitat availability, based upon cutting schedules and the diversified animal communities expected to occupy those habitats, is the objective of a new program of habitat supply analysis (Patch 1987). The predictive capability of a model for integrated forestry-wildlife management requires basic data sets on species-specific habitat requirements.

In 1975, only 3000 ha of harvested forest on Crown Land in New Brunswick was converted to conifer plantations. In 1985 approximately 12 400 ha of 31 400 ha (39.5%) were replanted (Canadian Forestry Service, Fredericton, personal communication).

Small mammals represent a basic component in many natural terrestrial food chains and their temporal abundance often regulates the breeding success and survival of many terrestrial and avian predators (Hamilton and Cook 1945). Small mammals may also compete with man by feeding on conifer seeds and seedlings planted on cut-over sites to facilitate forest regeneration (Gashwiler 1959; Crouch 1976; Radvanyi 1970, 1975). Black (1969) provided a general review of the interactions between reforestation and wildlife communities in the northwestern United States, and Harris (1978) provided a comprehensive bibliography on the effects of forest management practices on wildlife ecology.

The distribution and abundance of small mammals in New Brunswick have been documented by collections dating back over 100 years. Dilworth (1984) provides a brief history of those collections, and the most recent compilation of the land mammals of New Brunswick. Other than a brief account of small mammals in the extreme southeastern portion of New Brunswick by Kirkland and Schmidt (1982), there are no published accounts of habitat selection by small mammals in the province. In Nova Scotia, a study by Swan et al. (1984), which examined the effects of various harvesting practices on small mammals in hardwood forest stands, is the only relevant published study in that province. In northeastern United States, the responses of small mammals to forest harvesting have been studied in Maine by Monthey and Soutiere (1985) and Clough (1987), in New York by Krull (1970) and in New Hampshire by Lovejoy (1975).

This study represents an initial effort to obtain data on small mammal communities in New Brunswick which can be used in models for predicting impacts on wildlife of specific types of forest management practices.

Study Area

The 12 sites sampled in 1981 were located in Albert and Kings counties in southeastern New Brunswick (Figure 1). Conifer plantations (since planting) and naturally regenerating sites (since cutting) were from 2 to 11 years old. In 1982 five sites were sampled in Victoria County in northern New Brunswick and represented some of the older (11-17 years) plantations in the province.

The 17 sites comprised seven spruce (*Picea* sp.) (2-17 years) and six Jack Pine (*Pinus banksiana*) (4-11 years) plantations, two clear-cuts left to natural regeneration (4 to 8 years old) and two mature (60+ years) spruce-Balsam Fir (*Abies balsamea*) control plots. Spruce plantations were either White (*Picea glauca*) or Black (*Picea mariana*) Spruce. The stocking rate of most plantations was approximately 2000 trees per ha. Most spruce plantations four years of age or older had received at least one aerial application of herbicide, especially the older plantations sampled in 1982 for which the precise history of chemical treatments was not available. The history of most plantations was conifer-dominated mature forest clearcut followed by site scarification and planting within 2-3 years of cutting. Two Jack Pine plantations were in old abandoned fields.

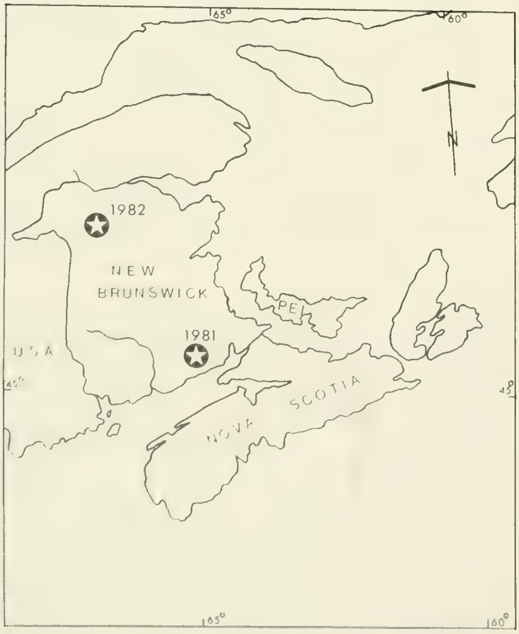

FIGURE 1. Locations of sites in New Brunswick sampled for small mammals in 1981 and 1982.

Methods and Materials

Small mammals were trapped on a 10 × 10 100 point grid having 12.5 m intervals between lines and stations. At each station, one Museum Special and one Victor snap trap were positioned at "most likely" sites within 2 m of the station marker. Traps were baited with a mixture of rolled oats and peanut butter. Each site was trapped for eight days from August through mid-September. A 6 m wide strip bordering each grid was included in the area from which small mammals were assumed to have been removed, providing for an effective sampling area of 1.55 ha.

Small mammals were collected early each morning and frozen the same day. Specimens were later thawed in the laboratory and species identification verified. Specimens of the family Soricidae were identified to species by tooth characteristics (Banfield 1974). Specimens were deposited at the New Brunswick Museum in Saint John, New Brunswick. Nomenclature follows that used by Dilworth (1984).

Each small mammal sampling grid fell within a larger 12.2 ha bird census study plot. This larger plot was sampled for plant community measurements. Habitat characteristics used here relative to small mammal communities included ground cover estimates for various plant community components. Ground cover values were from ocular estimation within 1 × 5 m plots systematically positioned within the larger 12.2 ha study area. Ground cover values for several vegetation classes were from 1 × 2 m subplots within the 5 m^2 plots. Small mammals were assigned to one of three trophic groups to facilitate statistical correlations with plant community measurements. Only data from the 13 plantations were used in these analyses.

Small mammal communities sampled at each site are described by the following measurements. Relative density is expressed as the number of small mammals removed per 100 trapnights (one trap in use for 1 night equals 1 trapnight (TN)). Absolute density (D) is the estimated number per ha. The estimated population size on each area trapped was first calculated from the multinomial method described by Zippin (1958). Population estimates used only the first seven days of trapping to take advantage of Zippin's graphical estimations of $\hat{p}$ (the estimated probability of capture during a single trapping) and $1-\hat{q}^k$ (the estimated proportion of the population captured). Total population estimates ($\hat{N}$) were converted to numbers per ha by dividing $\hat{N}$ by the size of the area effectively trapped (1.55 ha). Species richness (S) is the number of species trapped. Diversity (H') is calculated from the Shannon-Weaver formula

$$(H' = -\sum_{i=1}^{b} P_i \log_e P_i)$$

as used by MacArthur and MacArthur (1961) and Kricher (1972) to describe bird populations and Kirkland (1977) and Geier and Best (1980) to describe small mammal populations where p_i is the proportion of individuals in the ith species. Equitability (J') is a measure of the relative abundance of species in a community (Kricher 1972). It has also been called the relative abundance index (Tramer 1969) and the evenness component associated with the Shannon Index (Kirkland 1977). Equitability is calculated using the formula

$$J' = \frac{H'}{H'_{max}}$$

where H'_{max} is simply the natural logarithm of the number of species in the sample. Niche breadth (B) measures the distribution of a species in the sites (habitats) sampled, and niche overlap measures the similarity between proportions of individuals of two species in the sites sampled (Krebs and Wingate 1976).

Results

Species abundance and distribution within the sample

The importance of individual species within habitats and wildlife communities which constitute a specific ecological unit can be assessed by $\bar{x}$ (mean) relative densities (Table 1) and standardized niche breadth indices (Table 2). Twenty-seven hundred and seventy-seven (2777) small mammals were trapped in 27 200 trapnights (TN) for a trapping success (catch/unit sampling effort) of 10.2 small mammals per 100 TN. The sample included 11 species representing three families (Soricidae — 1535 (55.2%); Muridae — 1135 (41.0%); Zapodidae — 107 (3.8%).

The most abundant and ecologically widespread species of small mammal at the 17 sites sampled was *Sorex cinereus* (Masked Shrew) (41.7% of total sample). The least common species was *Sorex arcticus* (Arctic Shrew) which was also found at the fewest sites. *Clethrionomys gapperi* (Gapper's Red-backed Vole) was second only to the Masked Shrew in both abundance (19.8% of trapped sample) and niche breadth (Table 2). *Microtus pennsylvanicus* (Meadow Vole), although relatively common (third in relative abundance), was very unevenly distributed among habitats (second lowest in niche breadth) whereas the uncommon *Napaeozapus insignis* (Woodland Jumping Mouse) was found on a variety of sites sampled. Other species, such as *Peromyscus maniculatus* (Deer Mouse) and *Synaptomys cooperi* (Southern Bog Lemming) were moderate in both abundance and site distribution.

Population characteristics

Absolute density: The youngest spruce plantations (2-7 years) and clear-cuts left to natural regeneration (4-8 years) supported the greatest absolute densities of small mammals (Table 3). The lowest densities of small mammals were within the oldest (15-17 years) spruce plantations. The numbers of small mammals in the mature conifer forest habitat were significantly greater than in the older spruce plantations ($X^2 = 58.7$; $P < 0.001$). Absolute densities varied within spruce and Jack Pine plantations of intermediate age (8-12 years); such variation is attributed to site-specific physical and biotic characteristics which influence food and cover.

Species richness and community dominance: The number of species captured per site (species richness) varied from 5 to 11 and averaged 7.7 (Table 3). Differences in species richness were significant only between sites with the most (7-year spruce; 6-year Jack Pine) and the fewest (8-year Jack Pine) ($X^2 \geq 5.00$; $P < 0.05$) species. Community dominance, a measure of the extent that the two most abundant species dominate the total sample, showed no clear trend with habitat type (Table 3) and averaged 69.0%. The two most abundant species were most often *S. cinereus* and *C. gapperi*. *M. pennsylvanicus* was the most abundant species on two sites but was absent on five other sites. This species appeared to be the most sensitive to numerical fluctuations and it was most numerous where sites were adjacent to or near open fields.

Species diversity and equitability: Species diversity is an index which measures variation of the species elements of a community, and is a function of two separate components, species richness (the number of species) and equitability (the distribution of individuals among species) (Lloyd and Ghelardi 1964; Lloyd et al. 1968). Two communities may have similar measurements of diversity but, because the measurements of species richness and equitability are independent, the two communities might be very different (Kricher 1972).

In this study, measurements of small mammal community diversity varied from a low of 1.2 (8-year old field Jack Pine plantation) to 1.7 (4 sites) and averaged 1.4 (± 0.19) (Table 3). As with absolute density, diversity was greatest within the

TABLE 1. Relative densities of small mammals (catch/100 trap-nights[1]) in mature conifer forest, natural regenerating post-clear-cut seral stands and Jack Pine and spruce plantations.

	Type:	Mature[2] conifer	Natural regeneration		Plantations												
					Spruce							Jack Pine					
Species	Age (yr):	60+	4	8	2	7	11	12	15	16	17	4	5*	6	8*	10	11
INSECTIVORES																	
Masked Shrew *Sorex cinereus*		6.28	5.43	4.94	7.00	4.44	3.19	3.00	2.00	1.69	1.56	5.25	5.31	5.88	3.56	3.81	2.56
Pygmy Shrew *Sorex hoyi*		1.09	0.63	0.31	1.19	0.50	0.38	0.19	-	0.13	0.06	0.56	1.25	1.25	0.81	0.44	-
Smoky Shrew *Sorex fumeus*		-	-	-	0.44	-	-	0.95	0.25	-	0.06	-	-	0.06	-	-	0.38
Arctic Shrew *Sorex arcticus*		-	-	-	-	0.13	0.06	-	-	-	-	-	-	-	-	-	-
Short-tailed Shrew *Blarina brevicauda*		0.59	1.50	1.88	0.94	1.06	0.31	-	0.13	0.13	-	0.50	1.44	0.88	0.75	0.31	0.13
Subtotal		7.96	7.56	7.13	9.57	6.13	3.94	4.14	2.38	1.95	1.68	6.31	8.00	8.07	5.12	4.56	3.07
GRANIVORES-OMNIVORES																	
Deer Mouse *Peromyscus maniculatus*		0.16	1.25	1.19	2.44	1.13	0.81	0.13	0.25	0.50	0.25	0.06	-	0.38	-	0.38	0.06
Meadow Jumping Mouse *Zapus hudsonius*		-	0.19	0.38	0.44	0.25	-	0.44	-	-	-	-	0.50	0.25	0.06	-	-
Woodland Jumping Mouse *Napaeozapus insignis*		-	0.25	-	0.06	0.19	0.13	1.13	0.81	0.63	0.31	-	0.31	0.06	-	-	0.25
Subtotal		0.16	1.69	1.57	2.94	1.57	0.94	1.70	1.06	1.13	0.56	0.06	0.81	0.69	0.06	0.38	0.31
GRAZERS																	
Red-backed Vole *Clethrionomys gapperi*		2.28	3.69	2.38	2.88	0.38	2.44	2.69	1.88	2.38	0.81	1.50	0.31	0.81	1.19	1.31	3.44
Meadow Vole *Microtus pennsylvanicus*		0.59	6.56	0.63	-	7.38	0.06	1.44	-	-	-	0.38	0.75	1.00	-	0.13	0.13
Southern Bog Lemming *Synaptomys cooperi*		0.63	0.19	0.56	0.19	0.44	1.94	0.19	-	0.06	-	-	0.06	0.31	-	2.06	0.38
Subtotal		3.50	10.44	3.57	3.07	8.20	4.44	4.32	1.88	2.44	0.81	1.88	1.12	2.12	1.19	3.50	3.95

[1] Total trap-nights = 27 200; total small mammals = 2777.
[2] Average of two sites.
*Field plantations.

TABLE 2. Standardized niche breadth (Krebs and Wingate 1976) and mean relative abundance indices for 11 species of small mammals sampled by snap-trapping on 17 sites in New Brunswick.

Species	$\bar{x}$ relative abundance (catch/100 TN)	Standardized* niche breadth (B)
Sorex cinereus	4.25	0.88
Sorex hoyi	0.58	0.62
Sorex fumeus	0.11	0.28
Sorex arcticus	0.01	0.11
Blarina brevicauda	0.65	0.57
Peromyscus maniculatus	0.54	0.43
Zapus hudsonius	0.15	0.42
Napaeozapus insignis	0.24	0.39
Clethrionomys gapperi	1.92	0.78
Microtus pennsylvanicus	1.15	0.22
Synaptomys cooperi	0.45	0.33

$$*B = \frac{1}{\Sigma P_i^2} \,/\, \text{no. of sites sampled}$$

where $P_i = \frac{d_i}{\Sigma d_i}$

and d_i = no. of individuals per 100 TN in site$_i$.

B can vary from 0.0-1.0, where at 1.0, a species is found in equal density among all sites.

young spruce plantations and natural regenerating clear-cuts.

I ranked diversity indices for the 16 sites (2 mature softwood sites combined), grouped those values into five classes, and correlated those means with corresponding mean values for richness and equitability (Pearsonian coefficient of correlation). Both species richness ($r = 0.79$) and equitability ($r = 0.82$) showed positive correlation with community diversity.

Habitat selection

The relative abundance of small mammals among habitats, especially those sites which differ only marginally in the amount and distribution of physical and biotic properties (e.g. plantations of different ages) can be influenced by site-specific factors which often are not identified in practical habitat sampling strategies. In a study of the distribution of small mammals collected from a variety of habitat types, however, it would be incomplete not to measure some of the more obvious habitat properties and relate those measurements to small mammal abundance and distribution.

Associations between habitat variables and numbers of small mammals within three trophic groups (Rank correlation analysis) showed that only insectivores (Family Soricidae) were closely associated with age of plantation (numbers declined with age) (Table 4).

Insectivores are the primary pioneering trophic class of small mammals and they are most abundant in clear-cuts (plantation) shortly after forest removal. The positive correlation between ground cover of slash and Red Raspberry (*Rubus idaeus*) and the abundance of insectivores may be coincidental. Both habitat components, however,

TABLE 3. Characteristics of small mammal populations sampled in habitat types in New Brunswick in 1981 and 1982.

Habitat type(age in years)		Absolute minimum density (D)	Community dominance index[1]	Catch/unit effort (no./100 TN)	Diversity (H″)	Equitability (J″)	Species richness (S)
Mature conifer (60+)		98.4	73.7	11.6	1.4	0.76	6.5
Natural regeneration	(4)	166.6	60.9	19.7	1.7	0.76	9.0
	(8)	103.7	59.6	12.2	1.7	0.82	8.0
Plantations (clear-cuts)							
Spruce	(2)	131.7	63.5	15.5	1.6	0.72	9.0
	(7)	134.4	74.4	15.9	1.7	0.73	11.0
	(11)	78.8	60.4	9.3	1.6	0.73	9.0
	(12)	84.1	57.2	9.9	1.7	0.81	9.0
	(15)	44.9	72.9	5.3	1.4	0.78	6.0
	(16)	46.5	62.5	5.5	1.4	0.73	7.0
	(17)	25.9	77.5	3.1	1.3	0.72	6.0
Jack Pine	(4)	69.8	81.8	8.2	1.1	0.63	6.0
	(6)	92.1	65.5	10.8	1.5	0.68	10.0
	(10)	71.4	69.6	8.4	1.4	0.75	7.0
	(11)	61.9	82.0	7.3	1.3	0.64	8.0
Plantations (field)							
Jack Pine	(5)	84.1	67.9	9.9	1.4	0.71	8.0
	(8)	53.9	74.5	6.4	1.2	0.74	5.0

[1] Community dominance index = percentage of total individuals contained in two most common species (*after* Krebs and Wingate 1976).

TABLE 4. Relative degree of influence (Rank Correlation Coefficients[1]) of measured habitat variables and abundance of small mammals by trophic group within spruce and pine plantations (decreasing age vs. abundance; increasing % ground coverage vs. abundance).

	Rank correlation coefficients			
Habitat variable	Insectivores	Granivore-omnivore	Grazer	Total
Age (since planting)	+0.96	-0.29	-0.04	+0.74
% ground cover				
Brush and slash	+0.58	+0.22	-0.25	+0.57
Grasses, sedges, forbs	-0.51	-0.32	+0.41	+0.51
Raspberry	+0.69	+0.04	-0.25	+0.42
Foliage (≤ 2 m above ground)				
Deciduous	-0.17	+0.11	+0.52	+0.16
Conifer	-0.22	-0.24	+0.29	-0.15
Shrubs and heaths	-0.73	-0.45	+0.44	-0.53
Subtotal	-0.60	-0.22	+0.58	-0.36
Total ground cover	+0.19	-0.08	+0.29	+0.34

[1] $r \geq 0.50$; $p < 0.05$.
$r \geq 0.60$; $p < 0.01$.

contribute to cover and provide a microhabitat conducive to high insect densities. The negative correlation between insectivores and tree and shrub foliage ≤ 2 m above ground is also a function of site age, i.e. trees and shrubs do not contribute significantly to cover until a clear-cut, or plantation, has reached 8-10 years of age, about the time raspberry and brush and slash are rapidly declining in ground coverage importance.

In contrast to insectivores, the grazers (Microtinae) were positively correlated with increases in grasses, sedges and forbs and deciduous and conifer foliage ground cover values and inversely correlated with brush, slash and raspberry. Thus, a decline in abundance of insectivores with plantation age is offset by an increase (although normally of smaller numerical magnitude) in the grazers.

The high abundance of small mammals in the 4-year clear-cut left to natural regeneration confirmed the selection for early seral habitats by many small mammal species. At that site, *M. pennsylvanicus* was the most abundant species, an anomaly among sites sampled, believed attributable to adjacent open fields. Excluding *M. pennsylvanicus*, insectivores on the 4-year old site comprised 58% of the trapped sample (compared to 61% on the 2-year-old spruce plantation where no *M. pennsylvanicus* were trapped). The 8-year-old clear-cut left to natural regeneration supported fewer small mammals (103 removed per hectare) than the 4-year-old clear-cut (166 removed per hectare) although the proportion of insectivores (58%) had not changed from that on the younger site. Small mammals were only slightly more abundant on the two youngest spruce plantations (2- and 7-year: $\bar{x} = 200/\text{ha}$) than the two clear-cuts left to natural regeneration (4- and 8-years: $\bar{x} = 179/\text{ha}$).

Removal rates

An estimate of the proportion of a species within a community removed ($1-\hat{q}^k$) is a measure of "species trapability", as those species with a rapid decline in numbers caught through a discrete trapping period receive a higher value for $1-\hat{q}^k$ (Table 5). *Clethrionomys gapperi* was the small mammal most susceptible to being trapped (90% of estimated population removed through a 7-day trapping period) followed by *M. pennsylvanicus* and *S. cinereus*, both at 80%. *Synaptomys cooperi* was least vulnerable to trapping at only 46% of total estimated population removed.

There was a highly significant positive correlation between total individuals trapped per species and the estimate for the proportion of the species population removed (Spearman's coefficient for rank correlation = 0.90). The less common species have a reduced chance of being captured as many traps are quickly filled by the more abundant species. Thus, captures are less skewed over the trapping period, a factor contributing to lower vlaues of $1-\hat{q}^k$ and higher population estimates.

Catch curves (Figure 2) illustrate the temporal rates of removal for the three trophic groups. The disparate removal rates among groups were consistent throughout the 8-day trapping period. It can be seen that 50% of the estimated population of grazers was removed after 4 days of trapping but

TABLE 5. The distribution of small mammals removed through eight consecutive days of trapping for all 17 sites combined. The estimated proportions, by species, of total small mammals on the sites removed by trapping is also presented (*from* Zippin 1958).

	Consecutive trap-nights									% of $\hat{N}$ removed
Species/trophic group	1	2	3	4	5	6	7	8	Total	$(1-\hat{q}^k)$[1]
Insectivores										
Sorex cinereus	312	201	161	123	111	87	80	84	1159	0.80
Sorex hoyi	23	30	33	7	20	14	12	19	158	0.60
Sorex fumeus	8	6	1	1		9	5	2	32	*
Sorex arcticus	2				1				3	*
Blarina brevicauda	44	32	25	20	16	14	19	12	182	0.71
Subtotal	389	269	220	151	148	124	116	117	1534	0.77
Grazers										
Clethrionomys gapperi	183	101	75	62	43	26	24	35	549	0.90
Microtus pennsylvanicus	69	66	65	28	33	22	10	21	314	0.80
Synaptomys cooperi	16	24	24	10	15	15	11	11	126	0.46
Subtotal	268	191	164	100	91	63	45	67	989	0.86
Granivores-Omnivores										
Peromyscus maniculatus	29	24	33	14	14	11	15	7	147	0.67
Zapus hudsonius	9	5	3	6	7	1	5	4	40	0.57
Napaeozapus insignis	12	6	11	7	6	8	4	13	67	0.55
Subtotal	50	35	47	27	27	20	24	24	254	0.63
Totals	707	495	431	278	266	207	185	208	2777	0.80

[1] Proportion of theoretical population removed, using multinomial method of population estimation (Zippin 1958). To facilitate use of Zippin's multinomial charts, only 1st 7 trap-nights used in calculating % of $\hat{N}$ removed).
*Data too inconsistent.

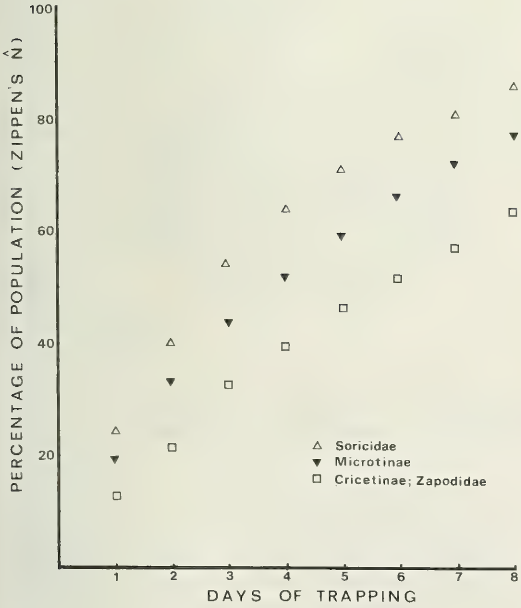

FIGURE 2. Catch curves for the three trophic groups of small mammals sampled within 17 habitat types in New Brunswick, 1981 and 1982.

that proportion of the less common granivores-omnivores was not reached until after 6 days of trapping. Those variables influencing the total proportion of species removed also influenced the disparities in the three catch curves (i.e., relative abundance and availability to be trapped).

Relative biomass estimates

The importance of species such as small forest mammals as components in ecological food chains can be evaluated by available biomass per unit area. I converted small mammal densities (no./ha) to available biomass (kg/ha) by multiplying numbers by mean body weights. Mean weights for individual species are from Banfield (1974) and are approximate only (e.g., *S. cinereus* — 4 g; *C. gapperi* — 20 g; *S. cooperi* — 28 g).

The grazers (Microtinae) were the principal contributors to total available biomass in all habitats sampled except for the two field Jack Pine plantations (Figure 3a), although the insectivores (Soricidae) were more numerous except on the 4-yr-old naturally regenerating site and the intermediate-aged spruce plantations (7-12 yr). The different proportions of numbers and biomass for the three trophic groups within the total sample of small mammals (n = 2777) are shown in Figure 3b.

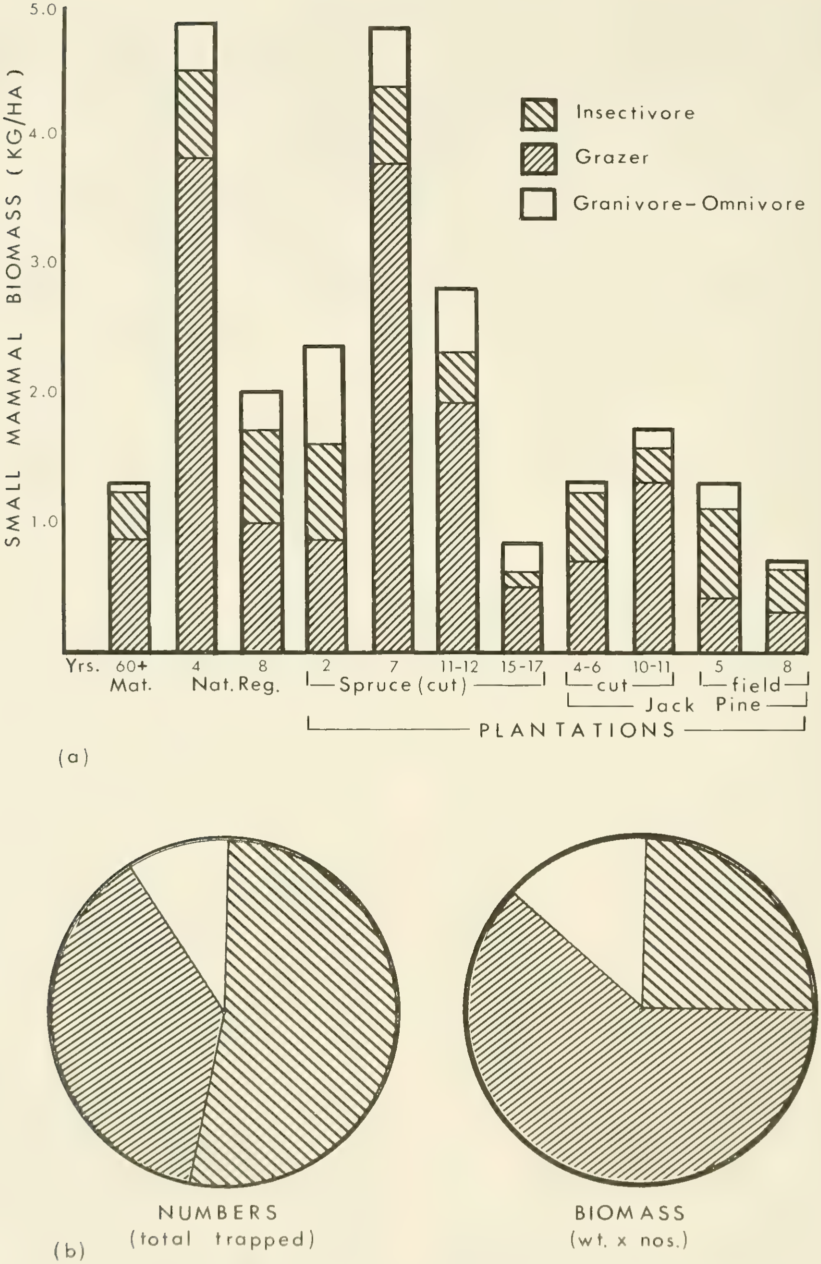

FIGURE 3. (a) Contribution to total biomass (kg/ha) by the three trophic classes of small mammals; (b) the importance of trophic groups relative to numbers and biomass in total small mammal sample (n = 2777).

Niche overlap

Niche overlap measures association between species. If two species are found in equal proportions among sites, niche overlap for those two species is 1.0. In this study, most of the common species were found on the majority of sites sampled, thus resulting in rather high niche overlap values (Table 6). As would be expected, the least common species, those which were found on only a few of the sites sampled, had the lowest niche overlap values. As many of the trap sites were in plantations only slightly different in age and

TABLE 6. Niche overlap[1] values for 11 species of small mammals and 17 sites sampled in New Brunswick in 1981 and 1982.

Species	*Sorex cinereus*	*S. hoyi*	*S. fumeus*	*S. arcticus*	*Blarina brevicauda*	*Peromyscus maniculatus*	*Zapus hudsonius*	*Napaeozapus insignis*	*Clethrionomys gapperi*	*Microtus pennsylvanicus*	*Synaptomys cooperi*	$\bar{x}$ species values (n = 10)
Sorex cinereus	1.00	0.93	0.38	0.28	0.86	0.71	0.70	0.39	0.83	0.50	0.56	0.61
S. hoyi		1.00	0.24	0.19	0.81	0.58	0.66	0.23	0.63	0.41	0.43	0.51
S. fumeus			1.00	-	0.04	0.14	0.56	0.73	0.58	0.11	0.12	0.29
S. arcticus				1.00	0.30	0.40	0.23	0.13	0.15	0.65	0.40	0.27
Blarina brevicauda					1.00	0.71	0.77	0.24	0.65	0.61	0.38	0.53
Peromyscus maniculatus						1.00	0.65	0.27	0.38	0.52	0.44	0.48
Zapus hudsonius							1.00	0.49	0.52	0.46	0.20	0.52
Napaeozapus insignis								1.00	0.59	0.30	0.14	0.35
Clethrionomys gapperi									1.00	0.40	0.47	0.52
Microtus pennsylvanicus										1.00	0.20	0.41
Synaptomys cooperi											1.00	0.33

[1] *After* Krebs and Wingate (1976).

species composition, high niche overlap values were not unexpected. Mean niche overlap values show that the most evenly distributed species relative to the others in the sample were *S. cinereus, Blarina brevicauda* (Short-tailed Shrew), *C. gapperi, N. insignis* and *Sorex hoyi* (Pygmy Shrew). The least abundant and most unevenly distributed species were *Sorex arcticus, S. fumeus, S. cooperi* and *M. pennsylvanicus.*

Discussion

The changes in small mammal communities in response to changes in habitat created by forest harvesting and subsequent regeneration described herein are similar to those described in northern Appalachian forests in West Virginia (Kirkland 1977) and in conifer forests of the Spruce-Fir-Northern Hardwoods Zone in Maine (Monthey and Soutiere 1985). Clough (1987) emphasized the importance of litter and ground and shrub layers to small mammal population density, richness and diversity in forest types in Maine.

Martell and Radvanyi (1977) found that species diversity rather than total density of small mammals showed the greatest change after clear-cutting of Black Spruce (*Picea mariana*) forests in northern Ontario. In the present study, the response to clear-cutting was one of initial numerical increase followed by a prolonged decline as plantations aged and microhabitat changed. This pattern is similar to that described for shrews after logging in coastal coniferous forests in Briitsh Columbia (Sullivan and Sullivan 1982). Others (Tevis 1956; Hooven and Black 1976) have documented opposite responses by small mammals to logging, and as stated by Sullivan and Sullivan (1982), the differential response to clear-cutting is probably most significantly influenced by geographical locality and characteristics of the original forest and subsequent clear-cut and plantation.

The mechanization of forest harvesting and subsequent site preparation for planting creates great diversity in regenerating site characteristics. Post-planting silvicultural treatments, such as herbicide application which decreases the deciduous component of habitat and thinning, contribute to changes in small mammal communities.

This study was time-specific, and results are subject to the many environmental variables which combined to create site-specific microhabitats. This study, as most others, had neither the time nor the resources to follow temporal habitat and small mammal numerical changes on specific study sites. Thus changes and relationships between plant and animal communities can only be measured by trends rather than relative correlations among variables. Many sophisticated multivariate analyses of wildlife populations with specific habitat measurements often are limited in their usefulness and, unfortunately, can be misleading by pointing to coincidental rather than real associations.

In eastern North America, it is only in the extensive southern pine plantations that studies have intensively examined the relationships between reforestation and wildlife communities (Harris et al. 1974; Johnson et al. 1974; Noble and Hamilton 1976; Repenning and Labisky 1985). Comparable studies in spruce and pine plantations in the northeast, especially in Atlantic Canada, are lacking, mainly due to more recent changes in forest harvesting (clear-cutting) and management (reforestation). New Brunswick presently leads the eastern provinces in the proportion of harvested forests converted to conifer plantations.

This study shows that small mammal populations generally respond in a predictable fashion to changes in habitat structure. Conifer plantations normally represent a habitat of more homogeneous structure than clear-cuts left to natural regeneration. The application of herbicides to suppress deciduous growth reduces plant diversity and cover which contributes to reduced diversity and numbers of small mammal populations. Diversity in stand structure not only leads to more wildlife abundance but may also mitigate the damage inflicted by forest pests upon large, uniform stands of planted conifers.

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Spawning, Growth, and Mortality of Three Introduced Fishes at Creston, British Columbia

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I studied spawning, growth and mortality of three introduced fishes, Yellow Perch (*Perca flavescens*), Pumpkinseed (*Lepomis gibbosus*), and Largemouth Bass (*Micropterus salmoides*), in the Creston Valley (Kootenay River watershed) of southeastern British Columbia from 1981 to 1986. All three species are abundant in lentic habitats. Pumpkinseed spawned between late May and early August. Largemouth Bass spawned between late May and late June. Growth of the three fishes was comparable to populations in the northwestern United States. Annual mortality of Largemouth Bass was lower than in populations in the United States, whereas annual mortality of Yellow Perch and Pumpkinseed was similar to populations in the United States.

Key Words: Yellow Perch, *Perca flavescens*, Pumpkinseed, *Lepomis gibbosus*, Largemouth Bass, *Micropterus salmoides*, spawning, growth, mortality.

In the late 19th and early 20th centuries, three introduced fishes, Largemouth Bass (*Micropterus salmoides*), Pumpkinseed (*Lepomis gibbosus*), and Yellow Perch (*Perca flavescens*) entered the Creston Valley of southeastern British Columbia, likely dispersing northward from Idaho through the Kootenay River (Carl et al. 1967). These, and a fourth introduced species, the Black Bullhead (*Ictalurus melas*), (*see* Forbes and Flook 1985) are now the dominant members of the fish community in lentic habitats, and are the primary forage for many fish-eating birds (Flook and Forbes 1983; Forbes 1985, 1987, 1989; Chapman-Mosher 1986; Ohanjanian 1986). The biology of Yellow Perch, Pumpkinseed, and Largemouth Bass in British Columbia is virtually unknown and here I report studies of spawning, growth, and mortality of these fishes in the Creston Valley.

Study Area and Methods

The study area included the shallow lakes and marshes of the Creston Valley Wildlife Management Area (CVWMA) on the floodplain of the Kootenay River, which flows northward to its confluence with Kootenay Lake, in southeastern British Columbia (Figure 1). Most of the flooded portion of the valley (83%) is contained behind dykes within the CVWMA (Butler et al. 1986). There are six major wetlands on the CVWMA, and I conducted fish surveys on three, Duck Lake, Corn Creek Marsh, and Leach Lake, between May and August, 1981 to 1986. Corn Creek Marsh and Leach Lake were flooded with less than one m of water; Duck Lake was flooded with less than two m of water.

Gill and seine nets were used for fish sampling. The gill-net consisted of five gangs of mesh (25 mm, 38 mm, 51 mm, 63 mm, 76 mm) 10 m by 2.5 m. Diurnal gill-net sets were 1-2 h long; night sets were 12 h. The seine net measured 20 m by 2.5 m and was set 25 m from shore by canoe. Fish lengths (total length) were measured to the nearest mm. Masses were measured with hand-held spring balances, with fish under 100 g measured to the nearest g and fish over 100 g measured to the nearest 5 g. Fish were released after measurement.

Scales were collected from Yellow Perch, Pumpkinseed, and Largemouth Bass taken in seine and gill-net catches at Duck Lake in 1982. I attempted to obtain as broad a range of sizes of fish as possible. Five scales from each fish were inspected under a microscope (4-10× magnification) to determine the number of annuli.

Instantaneous mortality rates (Z) were calculated according to Ricker (1975) as the descending slope of the natural logarithm of the frequency of age N vs age N. After determining Z, the annual mortality rate (A) was calculated from the equation: $1 - A = e^{-z}$ where $e = 2.718 \ldots$ Age-length keys were assembled from data collected on the three species at Duck Lake in August 1982 and were used to determine the abundance of each age class in the net catches. Seine data were used in preference to gill-net data for Yellow Perch and Pumpkinseed because of the tendency for gill-nets to sample larger fish more efficiently (Hamley 1975). However, gill-net data were used for Largemouth Bass because too few bass were taken in seine hauls. Bass grew to sizes which exceeded the selective range of the gill-net (year-class VII or older bass were too large to gill in the net; when captured they were either tangled or had swallowed smaller fish trapped in the net). These

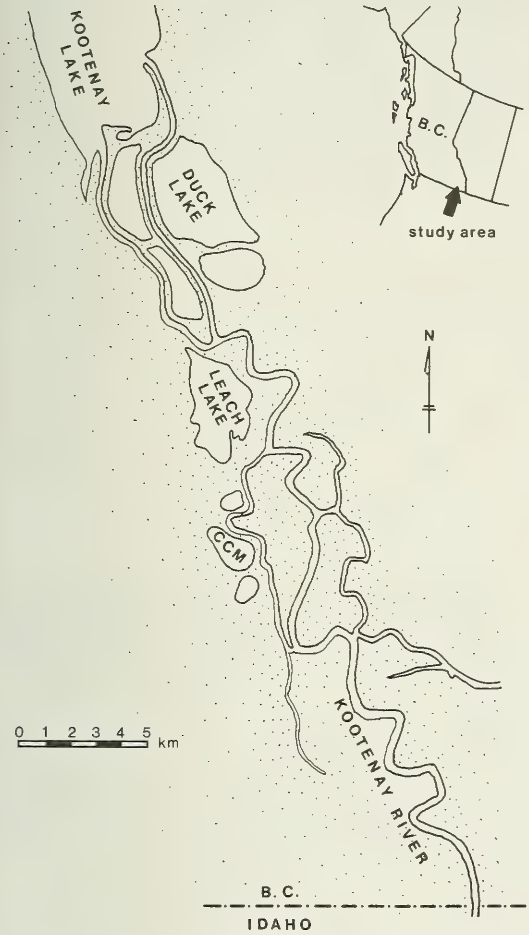

FIGURE 1. The Creston Valley of southeastern British Columbia. The locations of the Kootenay River, Kootenay, Duck and Leach Lake, and Corn Creek Marsh [CCM] are shown.

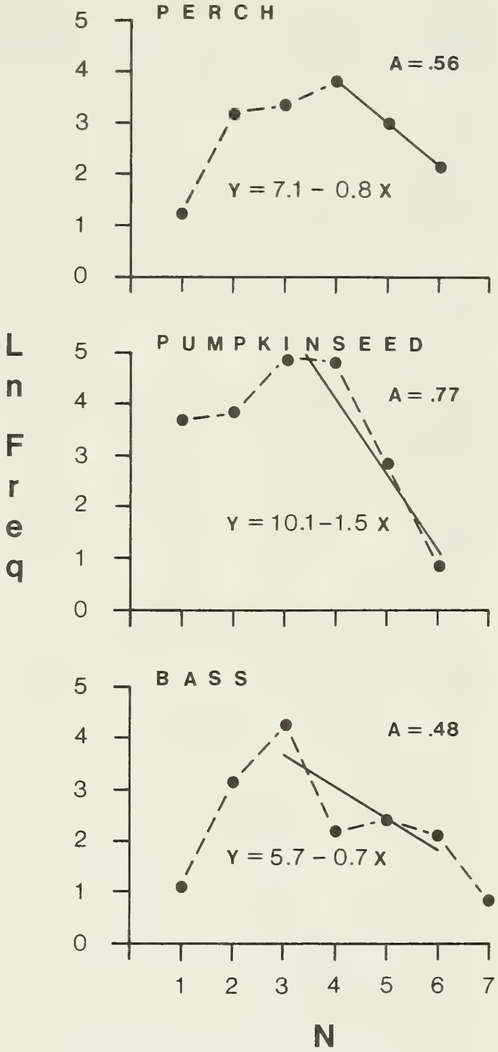

FIGURE 2. Catch curves (natural logarithm [Ln Freq] of frequency of age N fish vs age N [N]) for Yellow Perch and Pumpkinseed in seine hauls, and Largemouth Bass in gill-net sets, in Duck Lake in August 1982. Regression line is fitted to the descending right hand limb of the curve (regression slope = Z). Regression equation and annual mortality rate [A] are shown.

year classes of bass were excluded from mortality rate determinations. The spawning chronology of bass and Pumpkinseed was determined from direct observations of fish on nests.

Results and Discussion

Spawning

Largemouth Bass spawned in Duck Lake between 20 May and 24 June at water temperatures between 20° and 23° C. Peak spawning occurred in early June. Nests were found in water 50 to 103 cm deep ($\bar{x} = 73.5$ cm, S.D. = 1.9, n = 10). This spawning chronology is similar to that reported for Montana and Washington (Brown 1971; Wydoski and Whitney 1979).

Pumpkinseed spawned between 20 May and 5 August in Duck Lake, Corn Creek Marsh and Leach Lake, at water temperatures between 16° and 23° C. Peak spawning occurred in early to mid-June. Nests were found in water 25 to 103 cm deep. Nesting aggregations were observed in Corn Creek Marsh in water 25 to 46 cm deep. Ninety-four nests occurred in 100 m^2 in one aggregation on 4 July 1981. The smallest spawning males and females

TABLE 1. Total lengths (mm) of different year-classes of Yellow Perch, Pumpkinseed, and Largemouth Bass at Duck Lake, British Columbia. Mean total length (x), sample size (n), and range (min and max) are shown. See text for description of growth of young-of-the-year (year-class 0) perch and Pumpkinseed.

	Year Class											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Yellow Perch												
$\bar{x}$	123	172	182	202	221	240	-	-	-	-	-	-
n	17	11	24	14	4	2	-	-	-	-	-	-
min	81	123	148	160	199	224	-	-	-	-	-	-
max	148	227	220	238	247	256	-	-	-	-	-	-
Pumpkinseed												
$\bar{x}$	106	121	131	161	164	188	-	-	-	-	-	-
n	7	22	8	4	4	2	-	-	-	-	-	-
min	95	94	115	144	144	178	-	-	-	-	-	-
max	125	161	141	183	180	198	-	-	-	-	-	-
Largemouth Bass												
$\bar{x}$	142	152	237	268	292	384	430	470	431	475	-	507
n	1	3	12	4	4	1	1	1	3	2	-	1
min	-	147	185	215	233	-	-	-	421	430	-	-
max	-	159	324	350	355	-	-	-	446	520	-	-

were both 88 mm, indicating first spawning at year-class I or II. The spawning chronology of Pumpkinseed at Creston is similar to that reported for Montana, Idaho, and Washington (Brown 1971; Simpson and Wallace 1982; Wydoski and Whitney 1979).

Growth

Young-of-the-year (year-class 0) Yellow Perch grew from 36.8 mm (S.D. = 6.5 mm, n = 83) on 20 July 1982, to 48.1 mm (S.D. = 6.7 mm, n = 55) on 24 August 1982 at Duck Lake. Over the same time period, young-of-the-year Largemouth Bass grew from 32.8 mm (S.D. = 3.7 mm, n = 26) to 53.3 mm (S.D. = 4.5 mm, n = 3).

Early growth of Yellow Perch (year-class I to IV) in Duck Lake was faster than in three Montana ponds, but growth of older perch appears slower (Table 1; Brown and Logan 1960). Growth of all ages of perch in Washington is considerably faster than in Duck Lake (Table 1; Wydoski and Whitney 1979).

Growth of Pumpkinseed was higher in Duck Lake than in Montana (Table 1; Brown and Logan 1960) and exceeded the growth of nearly all the populations (predominantly from the continental United States) reported in Carlander (1977). I suspect that the mean length of year-class I Pumpkinseed (Table 1) is overestimated. Small Pumpkinseed (< 75 mm) appeared abundant in dense submergents (estimated visually) but rarely appeared in seine catches, and hence were not included in the sample for age determination. The mean length of year-class I Pumpkinseed thus is likely biased toward faster growing individuals which move sooner to open water and are more vulnerable to seine hauls.

Largemouth Bass in Duck Lake grew faster than in Montana but slower than in Washington (Table 1; Brown 1971; Wydoski and Whitney 1979). Brown (1971) noted that the slow growth of Largemouth Bass in Montana was due to low water temperatures. Growth of bass in Duck Lake was slower than nearly all Largemouth Bass populations (predominantly from the continental United States) reported in Carlander (1977). Slow growth is characteristic of northern populations of Largemouth Bass (Carlander 1977).

Mortality

Annual mortality (A) for year-class III to VI bass in Duck Lake was estimated at 48% (Figure 2). Carlander (1977) reported values of A from 19.5 to 92% for other populations of Largemouth Bass; in most cases (17 of 27), A exceeded 48% (*see* Carlander 1977: 260) and a trend for lower mortality rates in northern populations is evident in data presented in Carlander (1977).

Annual mortality for year-class III to VI Pumpkinseed in Duck Lake was estimated at 71% (Figure 2), which is lower than mortality rates of 88%, 80% (year-class II-III), and 88% (year-class III-IV) reported for Pumpkinseed in Indiana lakes (Ricker 1945, 1955).

The annual mortality of year-class IV to VI Yellow Perch in Duck Lake was estimated at 56% (Figure 2); Heyerdahl and Smith (1971) reported a similar value (57%) for exploited populations of Yellow Perch in Minnesota.

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Autumn Migration and Comments on the Breeding Range of Bonaparte's Gull, *Larus philadelphia*, in Eastern North America

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Sightings of breeding adults and fledged juvenile-plumaged birds indicate that the breeding range of the Bonaparte's Gull extends east beyond the Ontario-Quebec border. During autumn migration, Bonaparte's Gulls use three flyways: the Pacific, Mississippi and Atlantic, with the majority (60%) following the Mississippi Flyway from the Great Lakes to the Gulf of Mexico and the remainder of the population split between the two coasts (Atlantic: 21%, Pacific: 19%). Arrival and departure dates at various major stop-over areas were used to map details of the probable migration routes, particularly in eastern North America. The Atlantic Flyway was utilized for varying stretches by birds arriving from the breeding grounds mainly via the following routes: a) Saguenay River — Upper Saint John River – St. Croix River — Quoddy region, southwestern Bay of Fundy, b) Lower Great Lakes — Mohawk River — Hudson River — Long Island, New York area, and c) Lower Great Lakes — Delaware River – Delaware Bay/Chesapeake Bay.

Key Words: Bonaparte's Gull, *Larus philadelphia*, breeding range, migration.

The Bonaparte's Gull, *Larus philadelphia* (Ord), is a widely distributed North American species, yet relatively few details are known of its breeding range and migratory habits. The breeding range is generally accepted as including western and central Alaska, and the coniferous belt of western and central Canada, with only a few records east of the Ontario-Quebec border (Godfrey 1986). Unlike most larid species, the Bonaparte's Gull does not nest colonially. The nest is placed in a coniferous tree, usually in the vicinity of a muskeg lake or pond, making human access for study or census difficult.

The Bonaparte's Gull does not have an apparent mass migration during spring or autumn like loons or other waterfowl. Instead, the birds fly in loose flocks which comprise thousands. Coastally, the Bonaparte's Gull is more pelagic than most of its tribe (Lowery 1955), often feeding offshore (Pough 1951).

The objective of this study was to describe the autumn migratory movements of Bonaparte's Gulls in eastern North America and present some evidence suggesting an eastern extension of the known breeding range.

Methods

Enquiries regarding arrival and departure dates as well as population estimates of Bonaparte's Gulls were made of 40 amateur and professional ornithologists in eastern North America during 1981-1984. Replies from 29 people generated useful data in the form of cruise, museum, and personal records, and local ornithological bulletins. This information, in conjunction with other records from the published literature, formed the data base for the description of autumn migratory routes and probable eastern extension of the breeding range of the Bonaparte's Gull.

Translation of sighting data/accounts into proposed migration routes was based solely on numbers sighted, locations, and dates. Migration routes were derived from the data using the following criteria: (1) the birds follow the river/lake systems, (2) the general direction of movement should lead southward, and (3) the routes must concur with recorded arrival and departure dates, and numbers of birds sighted at the various locations.

A total population estimate for North America, as well as local population estimates for late December — early January, was based on Christmas Bird Counts summed annually for 1980-81 (Heilbrun et al. 1981), 1981-82 (Heilbrun et al. 1982), 1982-83 (Heilbrun et al. 1983), and 1983-84 (Rubega et al. 1984), and averaged over the four years. These counts were used as a crude index of the total North American population after it left the breeding grounds and formed large local aggregations before continuing on to the wintering areas.

Results and Discussion

Eastern Breeding Range

Knowledge of bird distribution in the Gaspé Peninsula in southeastern Quebec is poor (R. Bisson, personal communication), and most of Quebec north of the Saguenay River is ornithologically unexplored (M. Gosselin, personal communication). The types of muskegs, ponds, and lakes that the Bonaparte's Gull frequents during the breeding season are, however, present in the coniferous zones of Quebec. Several nesting locations of Bonaparte's Gulls have been recorded in Quebec: (1) 1977 — Pointe Racine, Lac Saint-Jean (Quebec Nest Record Card Program), (2) 1982 — about 100 km up the Eastmain River (Gosselin and David 1982), and (3) 1983 — near Rouyn (David 1983) (Figure 1). Aerial surveys, conducted by the Canadian Wildlife Service, Quebec Region, over the Eastmain, Opinaca and Petite Opinaca Rivers east of James Bay in Quebec, recorded maxima of 12 and 15 Bonaparte's Gulls during early June of 1981 and 1982, respectively (Y. Aubry, unpublished data). A pair of Bonaparte's Gulls with three downy young were observed at Saint-Gedeon on 5 July 1987, providing a new nesting locale for Lac Saint-Jean's small, disjunct breeding population (Yank et al. 1987), and a previously known colony of Bonaparte's Gulls was found on Lac Fleuricourt (near Lac Mistassini) on 8 July 1988 (Gosselin et al. 1988). Farther east, there is a record of a fully-fledged juvenile-plumaged bird as early as 25 July 1975 at Bonaventure on the north shore of Baie des Chaleurs in the Gaspé Peninsula (M. Gosselin, personal communication), and as early as 23 July 1984 in the Quoddy region off southeastern New Brunswick (Braune 1987).

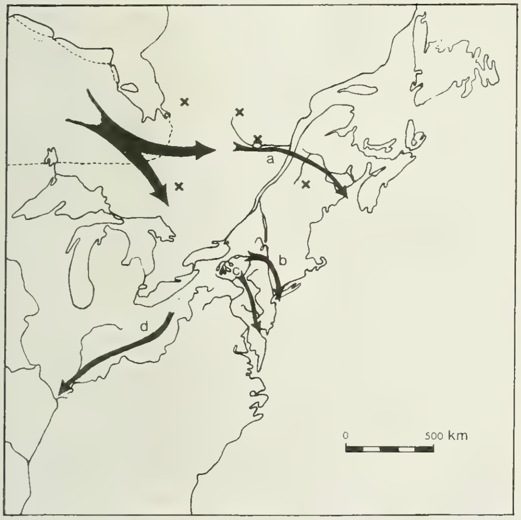

FIGURE 1. Eastern breeding range ▨ of the Bonaparte's Gull, and known or assumed nest sites x located in Quebec and Maine. The three main eastern migration routes to the Atlantic coast are as follows: a) Saguenay River — Upper Saint John River — St. Croix River — Quoddy region, southwestern Bay of Fundy; b) Lower Great Lakes — Mohawk River — Hudson River — Long Island, New York area; and c) Lower Great Lakes — Delaware River — Delaware Bay/ Chesapeake Bay. Most of the birds from the Lower Great Lakes, however, migrate via: d) the Mississippi River system.

In northwestern Maine, copulatory and aggressive behaviour by Bonaparte's Gulls have been observed at Allagash and Caucomgomac Lakes, and a used nest assumed to belong to a Bonaparte's Gull was found in a spruce tree located at Allagash Lake (Lucey 1983). Lake rangers believe that Bonaparte's Gulls have been nesting in the area over the past years, but they have no documented proof. It is likely, therefore, that some birds have always nested in Quebec and other areas farther east, but remained undetected because of the difficult terrain and the isolation of their nests.

Autumn Migration

Bonaparte's Gulls follow three of the major flyways: the Pacific, Mississippi, and Atlantic (Figure 2). The birds leave the nesting grounds during August — September and begin arriving at their overwintering grounds about November regardless of which flyway is used (Figure 2).

Numbers of Bonaparte's Gulls recorded by Christmas Bird Counts during 1980-1984 yielded a mean North American population estimate of about 130 000 ± 45 000 birds. Average distribution of birds during those counts placed about 19% of the population along the Pacific coast, 21% along the Atlantic coast, and 60% along the Mississippi Flyway from the Great Lakes to the Gulf of Mexico (Figure 3).

Nonbreeding individuals and those finished nesting gather on lakes and rivers, then along the coast, bays, harbours, and sandbanks in preparation for autumn migration (Godfrey 1972). In autumn, the birds are more abundant along the coast where they feed offshore over tide channels, rips, and kelp beds (Pough 1951). The birds are more at home on lakes than on rivers and when seen on the latter, they are migrating and not resting en route (Todd 1940).

The main wave of gulls migrates through Quebec during August — October with peak numbers passing through central and southern Quebec during late August — early September (David 1980). Although numbers of Bonaparte's Gulls also migrate regularly along the Northumberland Strait during that period (Godfrey 1954; Boyer 1966), the birds rarely cross the Isthmus of Chignecto separating the Strait from the upper Bay of Fundy (Boyer 1966). Accordingly, in the Bay of Fundy, Bonaparte's Gulls are abundant only in the Quoddy region off southeastern New Brunswick, and are uncommon on the middle and upper Bay of Fundy and lower Saint John valley (D. S. Christie, personal communication). The

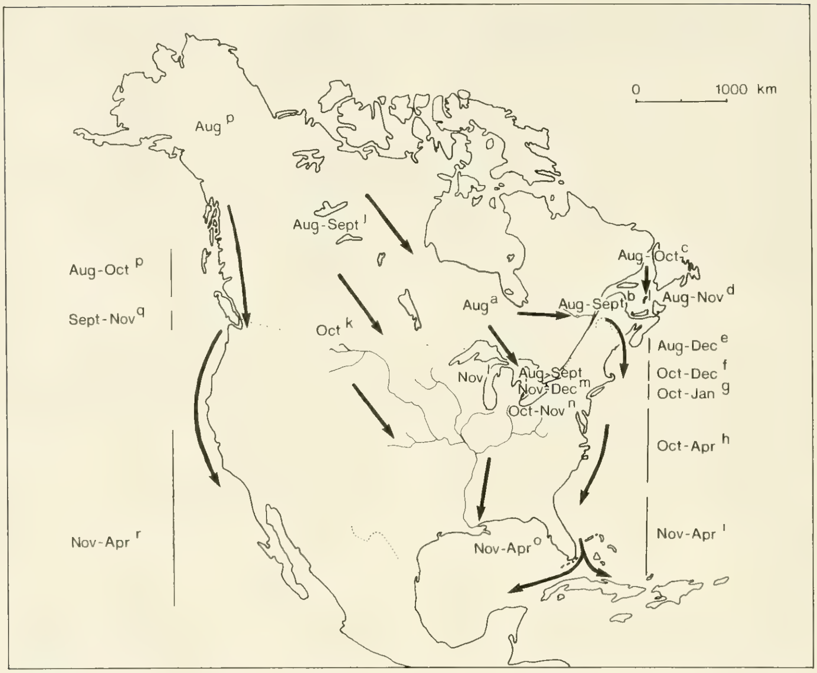

FIGURE 2. Routes of autumn migration showing approximate dates when Bonaparte's Gulls are locally abundant during autumn-winter. **Atlantic Flyway** — a: Moosonee, Ontario (R. D. McRae, personal communication), southwest coast of James Bay (R. I. G. Morrison, personal communication); b: Saguenay River, Quebec, Baie des Chaleurs, New Brunswick (David 1980); c: west coast of Newfoundland (J. Wells, personal communication); d: Baie Comeau (Harper 1958), Magdalen Islands, Quebec (Y. Aubry, personal communication), Gulf of St. Lawrence (David 1980), salt marsh between Percé and Gaspé, Quebec (Wiseman 1976), Northumberland Strait (Boyer 1966), Prince Edward Island (Godfrey 1954), Cape Breton Island (Godfrey 1958); e: Quoddy region, New Brunswick (Braune 1987); f: Nantucket Island, Massachusetts (B. Nikula, personal communication), Boston-Newburyport, Massachusetts (R. S. Heil, personal communication), Massachusetts (R. A. Forster, personal communication), Rhode Island (Pettingill 1951); g: Long Island, New York (R. G. Spahn, personal communication), Long Island and coastal New York (Cruickshank 1942; Burger and Brownstein 1968); h: Old Cape May, New Jersey (Stone 1937) Delaware Valley (Brady et al. 1972), Maryland (Robbins and Bystrak 1977), Virginia (Larner et al. 1979); i: North Carolina, Georgia (Pettingill 1951), South Carolina (Sprunt and Chamberlain 1949), South Carolina, Florida (K. D. Powers, personal communication), Florida (M. M. Simons, Jr., personal communication). **Mississippi Flyway** — j: Churchill, Manitoba (Jehl and Smith 1970), northwestern Alberta (Gunn et al. 1975); k: Alberta (Wedgwood 1982), Montana (Lambeth 1982); l: Lake Michigan (Pettingill 1951); m: Sarnia, southwestern Ontario (A. H. Kelley, personal communication), Niagara River eastern Lake Erie region (Beardslee 1944), northwestern New York (R. G. Spahn, personal communication); n: Ohio (Pettingill 1951), Pennsylvania (Poole 1964); o: Gulf coast west of Tallahassee, Florida (H. M. Stevenson, personal communication), Gulfport, Mississippi (Pettingill 1951), Mississippi and Alabama (K. D. Powers, personal communication), coastal Louisiana (Lowery 1955). **Pacific Flyway** — p: southeastern Alaska (Siegel-Causey and Meehan 1981), British Columbia (Guiguet 1971); q: Active Pass, British Columbia (Vermeer 1977); r: Monterey Bay, California (Baltz and Morejohn 1977), Baja California to Sonora and Sinaloa, Mexico (Friedmann et al. 1950).

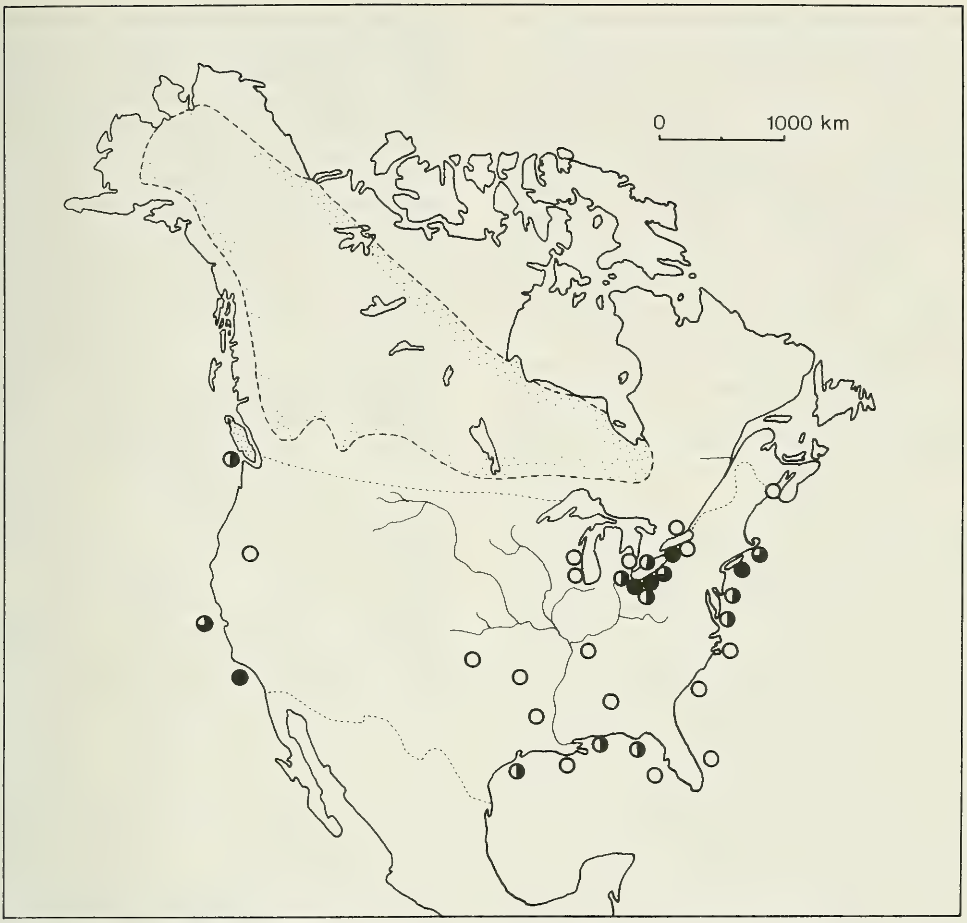

FIGURE 3. Breeding range (Godfrey 1986) of the Bonaparte's Gull, and the distribution of this species across North America during Christmas Bird Counts (17 December-4 January) averaged for the four years 1980-84. Average numbers of birds counted are as follows: ○ 100-1000; ◑ 1001-5000; ◕ 50001-10 000; ● 10 001-20 000.

birds found staging in the Quoddy region probably follow the inland river-lake systems from the mouth of the Saguenay River and the Gulf of St. Lawrence to the upper Saint John River and then to the St. Croix River leading into the Quoddy region (Figure 1). There are few birds left in the Quoddy region by late December — early January (Braune 1987).

The majority of the birds pass down the coast of Maine in September without lingering (A. Rivers, personal communication). These are probably birds from the first wave through the Quoddy region (Braune 1987). In Massachusetts, the birds move rapidly through Cape Cod beginning in October, but large flocks assemble around Nantucket Island in late fall — early winter (B. Nikula, personal communication).

Bonaparte's Gulls pass by Rhode Island during mid-November-December, and are occasionally seen around New Haven Harbour, Connecticut, during November-March (Pettingill 1951). The reason so few birds are seen in Connecticut is probably because they are concentrated along Long Island, New York (Figure 3). One can follow the time sequence of arrival dates as the birds migrate down the Atlantic coast (Figure 2). Small flocks are occasionally seen during late August-September around Long Island and coastal New York, but the birds generally start to arrive in early October with peak numbers in mid-November (Cruickshank 1942). Peak numbers occur slightly earlier at Long Island than around Nantucket Island, Massachusetts, indicating an influx of birds probably from the Mohawk-Hudson inland water system to the Long Island area (Burger and Brownstein 1968) (Figure 1). Some of these birds may subsequently continue on to the Nantucket Island area to feed. The species is rarely seen migrating through the Adirondack-Champlain region (Burger and Brownstein 1968). Arrival periods of peak numbers in the Delaware Bay and Chesapeake Bay areas are earlier than for Long Island, again suggesting that numbers of birds migrate along the inland waterways (Finger Lakes — Delaware River (Burger and Brownstein 1968)) to the Atlantic coast. Although a few populations have been recorded as wintering at Jones Inlet, Montauk Point and New York City Harbour (Burger and Brownstein 1968), there are no major wintering populations off Long Island and the birds are gone by mid-January (R. G. Spahn, personal communication).

In the Niagara River — eastern Lake Erie region, there is an early wave during August-September which thins out in October, followed by a very large wave in November-December (Beardslee 1944). The size of the waves is just the reverse for the Quebec — Quoddy region birds (Braune 1987). The birds usually depart the Great Lakes region sometime in January, but of the thousands of Bonaparte's Gulls that migrate through the Niagara-Erie area, less than 3% are juveniles, suggesting that the latter migrate southward over a different route (Beardslee 1944). On the Atlantic coast, records for August-October 1979-1981 show a high proportion of juvenile birds off Newfoundland (J. Wells, unpublished data). Of all the birds surveyed by age in the Quoddy region during late July-November, about 13% were juveniles (Braune 1987) compared with less than 3% in the Niagara-Erie region (Beardslee 1944). During November 1976 off southern Maine, also about 13% of the Bonaparte's Gulls sighted were juveniles (K. D. Powers, unpublished data). The birds found in the northern Chesapeake Bight, however, were mainly adults (Rowlett 1980). This would suggest that many of those adult birds came from the Great Lakes region via the inland waterways as described earlier.

In some of the mid-southern states such as Oklahoma and Texas, the Bonaparte's Gull has become a fairly regular transient — probably as a result of so much water being impounded (Sutton 1967). The birds migrating through the interior probably join the flocks from the Great Lakes wintering in the Gulf of Mexico. The species is a rare winter resident along the Texas coast (Arnold and Kutac 1975), and is not as common along the peninsular Gulf coast of Florida as on the Atlantic side (L. S. Atherton, personal communication). Observations from a survey cruise conducted by the Manomet Bird Observatory during February 1980 indicate that Bonaparte's Gulls occurred locally off South Carolina, regularly off northern Florida, and were common off southern Florida. In the Gulf of Mexico, their occurrence was sporadic, except in the nearshore area of the Mississippi delta and Alabama where they were abundant (K. D. Powers, personal communication). The birds have been reported to winter as far south as Cuba and Haiti (Godfrey 1986). Sight records of "large flocks" at sea in the Gulf of Progresso off the Yucatan Peninsula still require confirmation (Friedmann et al. 1950). The birds could, however, follow the island chains from southern Florida to Haiti, and along the northwest coast of Cuba to the Yucatan Peninsula in Mexico (Figure 2). On the Pacific coast, Bonaparte's Gulls are fairly common winter residents from Baja California to Sonora and Sinaloa, Mexico, and inland in Jalisco and Guanajuato (Friedmann et al. 1950). A few Bonaparte's Gulls have also been seen or collected on Hawaii, Maui, Kaui, Laysan Island, and Midway Atoll (Berger 1972).

It has been shown that body size of Bonaparte's Gulls tends to decrease from east to west on the breeding grounds (Braune 1987). This information, in conjunction with body weight data for birds passing through the Quoddy region, suggests that most of the Bonaparte's Gulls of Ontario and Quebec migrate via the east coast whereas most of the birds from the Prairie Provinces and Northwest Territories probably migrate via the Niagara region (Braune 1987). Based on the given migration routes (Figure 1), there is probably some mixing of these populations during migration down the Atlantic coast south of the Long Island area. The movements of the west coast population are, however, much more likely to be isolated due to the geographical presence of the Rocky Mountain range which runs the length of the North American continent. Confirmation of these migratory patterns using morphometric data would be interesting because we have so little information for this species.

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Tadpole Development and Growth of the Great Basin Spadefoot Toad, *Scaphiopus intermontanus*, from Central Washington

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Laboratory development and growth of tadpoles of *Scaphiopus intermontanus* from a population inhabiting the sagebrush desert of north central Washington was monitored using tadpoles hatching from egg masses collected from natural pools, cultured at known density, food supply, and constant temperature (23°C). The duration of larval development to the completion of metamorphosis was 36 days: premetamorphosis 18 days, prometamorphosis 10 days, and metamorphic climax 8 days. At stage 25, shortly after hatching, mean total length was 9.6 mm. Tadpoles developed to maximal size at stage 40 when total length was 60.6 mm, with body length of 22.9 mm and body weight of 2.088 g. At the completion of metamorphosis (stage 46) body length was 20.5 mm and weight, 1.05 g. Tadpole mouthparts achieved maturity at stage 36, and the dental formula was 3 (3)/4 (1,2,3).

Key Words: Great Basin Spadefoot, *Scaphiopus intermontanus*, tadpole development, Washington.

Among desert amphibians members of the genus *Scaphiopus* are exceptional in their reproductive biology and show numerous adaptations for breeding in temporary pools: rapid embryonic and larval development, tadpole cannibalism, production of growth inhibitors by tadpoles, and high heat tolerance of tadpoles (Low 1976). However, there are relatively few reports on the development, growth and metamorphosis of spadefoot tadpoles, and most represent study of species from the southwestern United States: the Western Spadefoot, *S. hammondii* (Burgesss 1950), Plains Spadefoot, *S. bombifrons* (Voss 1961), Couch's Spadefoot, *S. couchi* (Mayhew 1965), and the Eastern Spadefoot, *S. holbrooki* (Semlitsch and Caldwell 1982). The present study reports the development and growth of tadpoles of the Great Basin Spadefoot, *S. intermontanus*, from a population inhabiting the Upper Sonoran sagebrush desert of central Washington.

Materials and Methods

Recently fertilized egg masses of *S. intermontanus* were collected on 20 May 1984 from shallow, temporary pools along a dirt road near Creston Butte (47° 44′ N, 118° 33′ W) in Lincoln County, Washington. [It is sad to report that a recent visit (June of 1988, to this breeding site now reveals that the natural sagebrush habitat has been eliminated and replaced by wheat fields, and the road is now paved with asphalt]. At hatching, tadpoles were reared in glass aquaria with a density of 25 tadpoles in 5 L of filtered pond water. The water in all containers was replaced each day and continuously aerated with an airstone. Each tadpole culture received a diet of par-boiled spinach: ration for the first week was 5 gm per day, and later 15 gm per day. Berns (1965) discouraged the use of spinach in the laboratory rearing of frog tadpoles because of a high mortality (after metamorphosis) apparently caused by kidney stones produced from the oxalic acid of spinach; however, in the present study and others (Brown 1967a, 1967b, 1969) I found no decrease in the viability of young spadefoot toads. All tadpole cultures were kept at room temperature (X = 23 ± 3°C) and exposed to natural photoperiod. At regular intervals, 275 individual tadpoles of *S. intermontanus* were preserved in an 8% formalin solution. All specimens were examined with a binocular dissecting microscope equipped with an ocular micrometer. Linear measurements were made with the ocular micrometer and vernier calipers to an accuracy of 0.1 mm; body weight (preserved sample air-dried for one minute) was measured by an electronic balance to an accuracy of 0.001 g. I used the staging system of Gosner (1960) to analyze the morphological development of spadefoot tadpoles. The development of larval mouthparts follows the standard suggested by Altig (1970).

Results

The postembryonic development of anuran tadpoles can be divided into three periods (Etkin 1968; White and Nicoll 1981): (1) premetamorphosis (stages 25 to 38) when there is much growth but little differentiation; (2) prometamorphosis (stages 38 to 42) when growth rate slows and morphological changes accelerate, and (3) metamorphic climax (stages 42 to 46) when dramatic changes in head, forelimbs and tail occur. Figure 1 shows the pattern of larval development and growth in *S. intermontanus*, and Table 1 summarizes the morphological variation at six developmental stages. Spadefoot tadpoles hatched from their jelly coverings on 21 May, and they were placed in culture dishes on 22 May. The first measurements of development were made 24 May when the tadpoles were in stage 25 (completion of opercular folds); the first sample showing complete metamorphosis at stage 46 (reabsorption of the tail) was 29 June. Thus, the total time of postembryonic development was 36 days; premetamorphosis required 18 days, prometamorphosis ten days, and metamorphic climax eight days. Nussbaum et al. (1983) reported that *S. intermontanus* metamorphose after one or two months of larval development.

During the period of premetamorphosis the rate of tadpole growth was very rapid. Mean total length increased from 9.6 mm (stage 25) to almost maximum size of 59.0 mm (stage 38); the maximal size of tail length (37.1 mm) was also reached at stage 38. Early development and growth of the hindlimb bud (stages 26 to 30) required five days, and differentiation of the hindlimb (stages 31 to 38) was another 13 days. The mean body weight of a tadpole increased from 0.030 g (stage 25) to 1.907 g (stage 38). Nussbaum et al. (1983) reported that hatchlings of *S. intermontanus* are 5 to 7 mm (total length) and that tadpoles reach a maximal size of 30 to 70 mm when they metamorphose.

The period of prometamorphosis appears rather simple and stable in *S. intermontanus*. Stages 39, 40 and 41 are recognized by development of subarticular tubercles on the hindlimbs and the loss of the cloacal tail piece. At stage 40, maximal size is reached in total length (60.8 mm), body length (22.9 mm), and tail length (37.9 mm); mean body weight is 2.088 g.

Emergence of the first forelimb (stage 42) was taken as an index of onset of metamorphic climax. At this stage total length had decreased to 43.6 mm, body length to 20.66 mm and tail length to 23.0 mm. At stage 43, when there is a complete reorganization of the head (eyes, jaws, muscles, hearing mechanism, and gill reabsorption) the mean body weight (2.857 g) is maximal. At the completion of metamorphosis (stage 46) the mean body length is 20.5 mm, and body weight is 1.008 g. This is a large decrease in body weight, but anuran larvae do not eat during metamorphic climax and there is loss of water from body tissues during transformation to the terrestrial stage (White and Nicoll 1981). Nussbaum et al. (1983) reported that body length in recently metamorphosed *S. intermontanus* from north central Oregon averaged 19 mm.

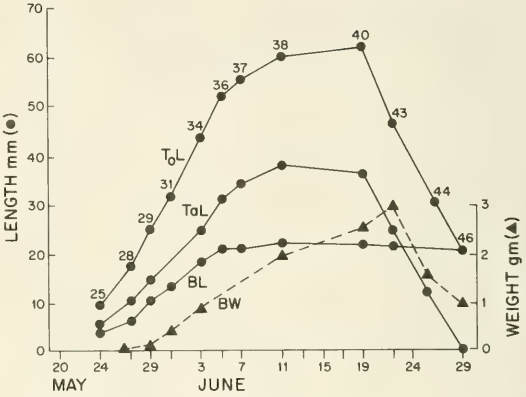

FIGURE 1. Growth and development of *S. intermontanus* tadpoles. Data show changes in body weight (BW), total length (ToL), tail length (TaL), and body length (BL) on selected dates of sampling. The stages of tadpole development are indicated at the points of the growth curve for total length.

Limbaugh and Volpe (1957) suggested that relative body ratios during larval development may be useful in taxonomic studies. Three ratios for *S. intermontanus* tadpoles from stages 25 to 41 are relatively constant (Table 1): BL/TL is 0.394, TaL/TL is 0.603, and TaH/TaL is 0.384.

The larval mouthparts of *S. intermontanus* show the basic pattern of the subgenus *Spea* described by Altig (1970): the oral disc is not emarginate, and there is a complete papillar border with a narrow dorsal gap. The mouthparts achieve complete development at stage 36 when the dental formula is 3(3)/4(1,2,3). There are three rows of uniserial teeth in the upper labium and four rows in the lower labium. The first and second upper rows are complete, but the third row has a large, median gap. In the lower labium the first and second rows have a large gap, the third row is the largest and has a small, median gap; the fourth row is the smallest and is complete. Wright and Wright (1949) report that dental tooth rows of 2/4, 3/4 and 4/4 may occur in *S. hammondii intermontanus* (now *S. intermontanus*).

Discussion

The reproductive biology of northern populations of spadefoot toads (*S. intermontanus* and *S. bombifrons*) inhabiting desert and grassland habitats is poorly known (Nussbaum et al. 1983; Green and Campbell 1984) and deserves further study (Preston and Hatch 1986). Breeding behavior and the development of embryos and tadpoles is better known for spadefoot toads (*S. hammondii, S. multiplicatus, S. bombifrons*, and *S. couchii*) from the southwestern United States

TABLE 1. Growth and development of tadpoles of *S. intermontanus*. Linear measurements in millimeters. Data show mean ± standard deviation and range; 25 tadpoles in each sample. BL = body length, ToL = total length, TaL = tail length, and TaH = tail height.

Date	Stage	Total Length	Body Length	Tail Length	Tail Height	BL/ToL	TaL/ToL	TaH/TaL
24 May	25	9.6 ± 0.5	3.7 ± 0.2	5.9 ± 0.3	2.7 ± 0.2	0.39 ± 0.03	0.61 ± 0.04	0.46 ± 0.03
		7.5 ± 10.3	3.4 ± 4.1	5.3 ± 6.6	2.5 ± 3.0	0.33 ± 0.42	0.56 ± 0.65	0.41 ± 0.52
31 May	31	31.8 ± 0.9	13.2 ± 0.7	18.6 ± 0.6	7.5 ± 0.5	0.41 ± 0.03	0.59 ± 0.02	0.40 ± 0.04
		29.6 ± 32.8	11.6 ± 14.7	16.6 ± 20.1	6.3 ± 8.6	0.39 ± 0.43	0.55 ± 0.64	0.35 ± 0.46
11 June	38	59.0 ± 0.9	21.9 ± 0.8	37.1 ± 0.8	13.4 ± 0.5	0.37 ± 0.03	0.63 ± 0.04	0.36 ± 0.05
		56.4 ± 62.3	18.7 ± 23.2	35.6 ± 38.9	11.9 ± 14.3	0.33 ± 0.42	0.57 ± 0.67	0.30 ± 0.43
19 June	40	60.8 ± 2.8	22.9 ± 1.3	37.9 ± 2.3	14.3 ± 1.3	0.38 ± 0.04	0.62 ± 0.05	0.38 ± 0.02
		57.2 ± 64.1	20.4 ± 23.7	35.3 ± 39.7	12.4 ± 15.8	0.33 ± 0.43	0.55 ± 0.69	0.35 ± 0.46
22 June	43	45.7 ± 1.4	21.3 ± 0.8	24.4 ± 1.3	10.0 ± 0.7	0.47 ± 0.06	0.53 ± 0.02	0.41 ± 0.03
		43.1 ± 47.6	19.7 ± 23.2	22.6 ± 26.6	9.3 ± 12.4	0.37 ± 0.42	0.51 ± 0.56	0.37 ± 0.45
29 June	46		20.5 ± 0.7			1.00 ± 0.00		
			18.9 ± 22.1			1.00 ± 1.00		

(Bragg 1965; Brown, 1967a, 1967b, 1969, 1976; Zweifel 1968).

Populations of *S. intermontanus* have probably benefited from greatly increased irrigation in the Great Basin (Nussbaum et al. 1983), and this spadefoot toad is widespread in the arid and semiarid regions of Washington (Slater 1955). In the northern portion of its range the breeding period may extend from April to June when eggs are laid in the shallow waters of ponds or lakeshore, and at warmer temperatures the eggs probably hatch within two or three days (Nussbaum et al. 1983).

The rapid development and growth of *S. intermontanus* tadpoles from the central Washington population is similar to that reported for other species of spadefoot toads: larval development required 36 days, and body length at the completion of metamorphosis was 20.5 mm. Burgess (1950) found that complete larval development of *S. hammondii* from southern California required four to eight weeks under controlled laboratory conditions. Childs (1953) compared the growth of normal and albino tadpoles of *S. hammondii* developing in natural pools in southern California: albino forms were smaller (total length 47 mm; weight 3.53 g) than the normal tadpoles (total length 58 mm; weight 4.08 g). Voss (1961) studied tadpoles of *S. bombifrons* developing in natural pools in west Texas: development was rapid and tadpoles reached a body length of 40 to 56 mm and metamorphosed after 15 to 20 days. Mayhew (1965) reported an extremely rapid rate of development in *S. couchii* tadpoles collected from natural pools in the Colorado Desert in southeastern California and cultured in the laboratory; fertilized eggs developed into tadpoles with four legs after only ten days of incubation.

The amphibian herpetofauna of the Pacific Northwest includes the extreme range of tadpole developmental rate among the anuran species of North America. While the Great Basin Spadefoot may complete larval development in about four weeks, tadpoles of the Tailed Frog (*Ascaphus truei*) that inhabit cold, montane streams of the North Cascades Mountains may require five summers and transform at the age of four years (Brown 1990).

Spadefoot tadpoles should provide a fascinating and interesting model for the study of larval differentiation, growth and metamorphosis where the following factors are evaluated in experimental tests: food level, larval density, growth inhibitors, competition and predation, and genetic variability (Hota and Dash 1981; Woodward 1982; Werner 1986; Newman 1987, 1988a, 1988b). However, before there can be a proper design of experiments to study these factors there is a need to understand the basic adaptations of tadpole morphology, ecology, and physiology in spadefoot toads.

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Zoogeographical Relationships of Aquatic Insects (Ephemeroptera, Plecoptera, and Trichoptera) from the Eastern James Bay Drainage

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An analysis of the aquatic insect fauna of the eastern James Bay drainage was conducted on the basis of specimens assembled in 1973-1982 during several impact studies related to the major hydroelectric projects conducted in the area. 220 species were collected in the orders Plecoptera (22), Ephemeroptera (50), and Trichoptera (148). The faunistic elements recognized include the Holarctic (16 species), the northern transcontinental (42), the continental (28), the central (1) various eastern (113), and the Appalachian (14) elements. Endemism (2 species) is probably only apparent, and the two species are likely to belong to wider ranging assemblages. The arctic element was totally lacking. Two main pathways for colonization are suggested, one from Northwestern refugia and another from Southern refugia, probably through the Mississippi-St. Lawrence waterways. Dispersal appears to have been greatest in Trichoptera and least in Plecoptera; respective importances of the transcontinental fauna vary from 14% (Plecoptera) to 47.3% (Trichoptera), while the eastern fauna represents from 47.3% in the Trichoptera to 71% in the Plecoptera. Comparisons with six Northeastern sites show a high similarity (80% in the Trichoptera) with two sites at corresponding latitudes, but only a moderate (< 50%) similarity with more southerly sites (46-47° N). Though the fauna has few original elements, its peculiarity resides in its species composition and its position at the entry point for western boreal elements into the Québec-Labrador Peninsula.

Key Words: Aquatic insects, mayflies, stoneflies, caddisflies, James Bay, distribution, zoogeography.

Extensive and intensive collections of aquatic biota were carried out in 1973-1982 in the eastern drainage of James Bay (Québec) as part of preimpoundment environmental studies for giant hydroelectric projects. These studies conducted by various teams under the auspices of the Société d'Energie de la Baie James (S.E.B.J.) accumulated a large number of aquatic insects. Though various reports and theses (see below) contain information on some of the species, no comprehensive discussion of the fauna and its zoogeographical relationships has been attempted, except on limited groups (Pilon et al. 1978; Landry and Harper 1985).

This paper presents a critical list of the species collected in the orders Ephemeroptera, Plecoptera and Trichoptera, shows the relationships of this fauna with other North American assemblages, and discusses its origins.

Materials and Methods

The specimens examined are from four sources: (1) a general survey conducted during the summer of 1973 in the areas of Lakes Sakami (Figure 1:C) and Attila (Figure 1:A) in the La Grande Rivière drainage, of River Opinaca (Figure 1:D), and of Lake Low (Figure 1:E) (Pilon and Méthot 1974; Pilon et al. 1978). (2) a systematic study of the aquatic habitats in and around Lakes Hélène and Nathalie (= Detcheverry) in the drainage of the Rivière au Castor (Figure 1:B) in the summer 1974 (Pilon et al. 1975). (3) a continuing study in the same area in 1975 concentrating on Lake Hélène and the Rivière au Castor (Fréchette 1976). (4) an impact study in 1976-1978, and 1982 on the development of a reservoir on Rivière Desaulniers (Figure 1:A) within the drainage of La Grande Rivière (Boucher et Lemire 1980; Hunter 1985).

Insects were collected mainly from emergence traps. Some light-trapping was also conducted.

All the material has been deposited in the Ouellet-Robert Entomological Collection of the Département de Sciences biologiques (Université de Montréal).

Study Area

The sampling area is situated in a rectangle delimited by the meridians 76° and 78° W and the parallels 52° and 54° N (Figure 1). It extends from the lower drainage of the La Grande Rivière to those of the rivers Opinaca and Eastmain. In Rousseau's (1952) classification, the region belongs to the mid-subarctic bioclimatic zone which is characterized by a growing season of 1000 to 1200 degree-days (above 5° C), a frost-free period of some 90 days, a mean annual temperature of between -1 and -4° C, and annual precipitation of the order of 60-70 cm, 35% of which comes as snow. The altitude is generally

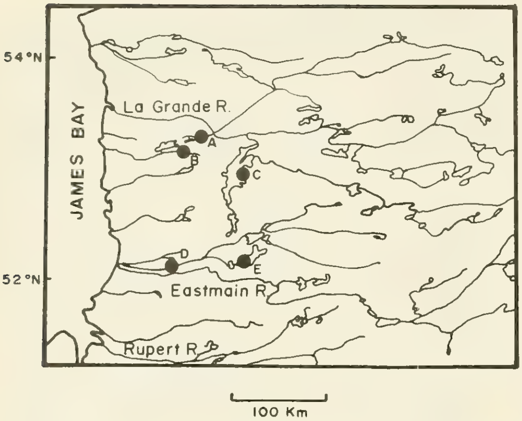

FIGURE 1. Map of the eastern shore of James Bay showing the main sampling sites: A: Lac Attila and Rivière Desaulniers, B: Rivière au Castor, C: Lac Sakami, D: Rivière Opinaca, E: Lac Low.

between 100 and 200 m. The region is part of the Eastmain and Larch Lowlands.

Following the last ice age, much of the area was covered by the Tyrrell Sea (Figure 3), an extension of Hudson and James Bays. The glaciers retreated and re-extended many times, the final retreat some 8000 years ago. The landscape is dominated by rolling hills of gneiss and granite interspersed with shallow glacial deposits (mainly clay and moraine), small glacial lakes, many aligned on an east-west axis, and many bogs. The terrestrial vegetation is dominated by open forests (10 to 55% cover) of Black Spruce (*Picea mariana*) (mean height 9 m) with an undercover of mosses and *Ledum* (Anonymous 1978).

The waters are slightly acidic (pH 6.2-6.8), unmineralized (conductivity = 14-38 umhos) and soft (hardness < 14 mg/L); phosphates are rare (< 0.07 mg/L), but total organic carbon is relatively high (4-19 mg/L). Surface temperatures reach 20°C in the summer.

The Fauna

Table 1 lists the 220 species from the three orders collected at the James Bay sites. Also indicated are each species' geographical distribution and its occurrence at comparison sites.

The geographical distributions are grouped into somewhat arbitrary types which for the most part follow Scudder (1979) and Nimmo (1971) and are based on commonly observed patterns; representative patterns are illustrated in Figure 2. In instances where it was not possible to assign a species to only one type, it was tallied in two categories, each as a half-unit.

Continental (CT): species which are found throughout most of North America, except in extreme environments.

Northern transcontinental (NT): species inhabiting the northern part of the continent, some extending south of the glaciated regions. NTd indicates a discontinuous distribution, with no records from central areas, and HL, Holarctic species.

Shield (SH): species with a wide distribution in the Northeast extending westwards into the Mackenzie drainage, but not crossing the Rockies. Some occur as far south as the Mississippi drainage.

Northeastern (NE): species typically distributed in the glaciated Northeast, but absent from the Prairies and the Northwest Territories.

Mississippian (MS): species whose distribution is centered on the Mississippi and Great Lakes-St. Lawrence drainages.

Appalachian (AP): species inhabiting the Appalachian range, often extending ito the Maritime Provinces and onto the Québec North Shore.

Cordilleran (CD): species typically distributed in the Rocky Mountains and other ranges of the Cordillera.

Central (CN): species colonizing the centre of the continent, the upper Mississippi drainage and the Great Plains (not illustrated).

The comparison sites are points of Québec and Ontario (Figure 3) from which data are available for comparison with the James Bay fauna (jb):

St. Martin Falls, Albany River (mf): specimens collected in the 1820s by George Barnston, a factor for the Hudson Bay Company, and deposited in the British Museum where they were studied by Walker (1852, Plecoptera [*see also* Ricker 1938, 1944; Trichoptera, *revised by* Betten and Mosely 1940] 1853, Ephemeroptera).

Algonquin Park (al): a stream system studied by Sprules (1947), with data on Plecoptera (*see also* Harper 1970) and Trichoptera.

Parc du Mont-Tremblant (tr): collections from the Rivière du Diable and tributaries; the Trichoptera were studied by Robert (1958) and Roy and Harper (1975), the Plecoptera by Ricker et al. (1968).

Station de Biologie de l'Université de Montréal, St-Hippolyte (sb): the Ephemeroptera were investigated by Harper and Harper (1982) and the Trichoptera by Roy and Harper (1981). The Plecoptera are from an unpublished list prepared by the author.

St. Lawrence River (sl): the Trichoptera are known from the study of Corbet et al. (1966) and the Ephemeroptera from Harper and Harper (1976).

Matamek River (mt): a partial list of Trichoptera is drawn from Williams and Williams (1979).

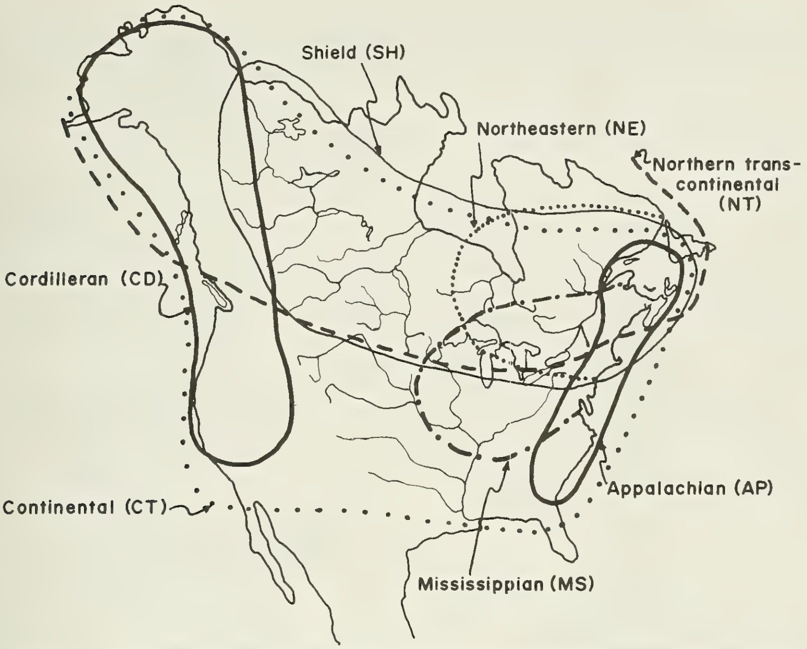

FIGURE 2. Distribution patterns used in this study (with abbreviations) superposed on a map of North America.

Ephemeroptera

Fifty species were collected of which 48 can be named (Table 1). Only one endemic element, *Caenis candida* (species number 44), was discovered (Harper and Harper 1981).

Three of the species are Holarctic (2, 6, 35), one is northern transcontinental (1), and eight continental (9, 11, 12, 31, 33, 46, 48, 49). The rest have an eastern distribution, most of these of type MS; some are Appalachian (5, 15, 28, 30, 40, 42, 50; *Siphloplecton basale* (5), though Appalachian, extends to the northwest to the Rockies). Finally one species (43) has a more south-central distribution (CN).

By comparison with other northeastern sites, the fauna is rich (45 species in sb and 25 in sl); about half the species are shared with the two southern sites (25/45, 11/25). Seven of the 11 species found at mf also occur in our list.

Fourteen species are exclusive to jb; of these, six are of particular interest and most are boreal (1, 3, 5, 6, 38, 39), particularly *Metretopus borealis* (6) and *Ameletus subnotatus* (1).

On the basis of early surveys (Harper et al. 1975; Harper and Harper 1981), other boreal elements, such as *Parameletus* spp. and *Rhithrogena jejuna* Eaton, would have been expected. No truly arctic species, such as *Baetis macani bundyae* Lehmkuhl and other specialized baetids (Harper and Harper 1981), were encountered.

Plecoptera

Twenty-two species (21 named) were found in the area. All are common, except a species (designated as *Cultus* cf. *aestivalis* (Needham and Claassen) by Stark et al. 1988) of Cordilleran affinities.

None of the species is Holarctic, and 3 are northern transcontinental (51, 54, 62). All the other species are restricted to the east, a majority (9 species) from the Mississippi-St. Lawrence fauna; 2 are Appalachian (61, 72).

The fauna is distinctly poorer than in the southern sites (31 species at al, 37 at sb, 31 at tr) and 10-11 species are common to jb and each of these sites. Of the 9 species known from the Albany River, only 3 (56, 62, 63) have been found in our samples.

Consequently, a number of northern species that were expected did not appear: *Allocapnia minima* (Newport), *Oemopteryx glacialis* (Newport), *Acroneuria lycorias* (Newman), *Isoperla citronella* (Walker), *Cultus decisus* (Walker), *Isogenoides olivaceus* (Walker), *Haploperla brevis* (Banks), *Acroneuria abnormis* (Newman), and *Paragnetina immarginata* (Say) from Ricker (1944); also lacking are *Paraleuctra sara* (Claassen), *Capnura manitoba* (Claassen), *Utacapnia labradora* (Ricker), *Zapada kathadin* Baumann and Mingo, *Taenionema atlanticum* Ricker and Ross, *Claassenia sabulosa* (Banks), *Helopicus subvar-*

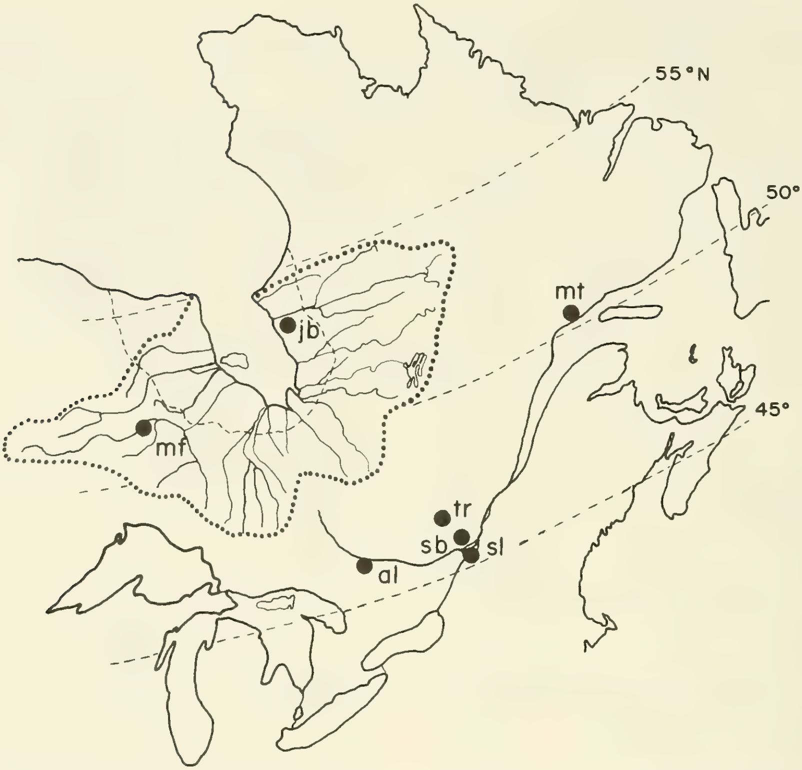

FIGURE 3. The James Bay drainage. The interrupted line around the Bay indicates the extension of the Tyrrell Sea. The comparison sites are also indicated: al: Algonquin Park, jb: this study, mf: St. Martin Falls, Albany River, mt: rivière Matamek, sb: Station de Biologie (St-Hippolyte), sl: St. Lawrence River, tr: Mont Tremblant Park.

ians (Banks), *Isoperla montana* (Banks), *Alloperla concolor* Ricker, *Suwallia marginata* (Banks), *Sweltsa naica* (Provancher), *S. onkos* Ricker from Ricker et al. (1968).

No truly arctic element (e.g. *Capnia sugluka* Ricker) was encountered, but 6 mostly boreal species (51, 56, 61, 64, 65, 66) did not occur in the southern comparison sites.

Trichoptera

The caddisfly list contains 148 species, which represents about half of those known from Québec (Roy and Harper 1979). Few seem to be endemic; *Oxyethira barnstoni* Harper has been shown to be Holarctic (= *O. mirabilis* Morton, *fide* Kelley 1982); *Goera radissonica* Harper and Méthot is still considered a valid species (Schmid 1983).

Twelve of the species are Holarctic and most of these are northern transcontinental; 38 others are northern Nearctic transcontinental, 8 of which have disjunct distributions (NTd), but in most species this is probably due to insufficient collecting. Twenty more are continental (CT). Some 47% of the species belong to a fauna widely distributed over at least the northern half of the continent. The others (47%) are typically eastern, again with a majority from the Mississippi-St. Lawrence fauna (36 species). Few are Appalachian (75, 77, 78, 129, 179 in part, 180, 217). One, *Wormaldia gabriella* (84), is Cordilleran.

Affinities with other subarctic faunas (mf and mt) are high with some 80% of species in common (25/31 at mf, 39/46 at mt). Similarity with more southerly sites is lower, generally of the order of 50% or less (26/52 at al, 76/170 at tr, 88/180 at sb, 37/99 at sl). By comparison with southern sites, there are 35 particular species, 5 of which are Phryganeidae and 15 Limnephilidae, the latter a dominant group in northern faunas (Lehmkuhl and Kerst 1979).

A few species, mainly from Walker's list, were expected but not found; these are *Chimarra obscura* (Walker), *Ceraclea mentiaea* (Walker), *Chilostigma aerolatum* (Walker), and *Brachycen-*

TABLE 1. List of the species collected in the eastern James Bay drainage (1973-1982). Also given are the distribution type (AP: Appalachian, CD: Cordilleran, CN: Central, CT: Continental, HL: Holarctic, MS: Mississippian, NE: Northeastern, NT: Northern Transcontinental, SH: Canadian Shield). The other symbols indicate presence of the species at the comparison sites (al: Algonquin Park, mf: St. Martin's Falls, mt: Matamek, sb: Station de biologie, sl: St. Lawrence River, tr: Mont Tremblant Park).

EPHEMEROPTERA		
Family Siphlonuridae		
1.	*Ameletus subnotatus* Eaton	NT
2.	*Siphlonurus alternatus* (Say)	HL — sb, sl
3.	*Siphlonurus quebecensis* (Provancher)	MS
4.	*Siphlonurus rapidus* McDunnough	MS
Family Metretopodidae		
5.	*Siphloplecton basale* (Walker)	SH/AP
6.	*Metretopus borealis* (Eaton)	HL
Family Baetidae		
7.	*Acerpenna pygmaea* (Hagen)	MS — sb
8.	*Baetis brunneicolor* McDunnough	MS
9.	*Baetis flavistriga* McDunnough	MS — sb
10.	*Baetis propinquus* (Walsh)	CT — sb
11.	*Baetis tricaudatus* Dodds	CT
12.	*Callibaetis ferrugineus* (Walsh)	CT — sb, sl
13.	*Centroptilum album* McDunnough	MS
14.	*Centroptilum rufostrigatum* McDunnough	MS — sb
15.	*Centroptilum venosum* Traver	AP
16.	*Cloeon rubropictum* McDunnough	NE
17.	*Cloeon* sp. 1	
18.	*Pseudocloeon parvulum* McDunnough	MS
19.	*Pseudocloeon* sp. 1	
Family Heptageniidae		
20.	*Arthroplea bipunctata* McDunnough	NE — sb, sl
21.	*Epeorus vitreus* (Walker)	NE — mf
22.	*Heptagenia lucidipennis* (Clemens)	NE
23.	*Heptagenia pulla* (Clemens)	NE — sb, sl
24.	*Stenacron interpunctatum canadense* (Walker)	MS — mf, sb, sl
25.	*Stenacron interpunctatum frontale* (Banks)	NE — sb, sl
26.	*Stenonema femoratum* (Say)	MS — sb
27.	*Stenonema vicarium* (Walker)	MS — sb, sl
Family Leptophelebiidae		
28.	*Habrophlebia vibrans* Needham	AP — sb
29.	*Leptophlebia cupida* (Say)	MS/SH - sb
30.	*Leptophlebia johnsoni* McDunnough	AP — sb
31.	*Leptophlebia nebulosa* (Walker)	CT — mf, sb
32.	*Paraleptophlebia adoptiva* (McDunnough)	MS — sb
33.	*Paraleptophlebia debilis* (Walker)	CT — sb
34.	*Paraleptophlebia mollis* (Eaton)	MS
Family Ephemerellidae		
35.	*Ephemerella aurivillii* Bengtsson	HL
36.	*Ephemerella* nr *excrucians* Walsh	NE
37.	*Emphemerella invaria* (Walker)	NE — mf, sl
38.	*Ephemerella needhami* McDunnough	NE
39.	*Ephemerella septentrionalis* McDunnough	NE
40.	*Euryllophella prudentalis* McDunnough	AP
41.	*Euryllophella temporalis* McDunnough	MS — sb, sl
42.	*Euryllophella verisimilis* McDunnough	AP — sb
Family Caenidae		
43.	*Brachycercus* prob. *prudens* (McDunnough)	CN
44.	*Caenis candida* Harper & Harper	—
45.	*Caenis forcipata* McDunnough	MS
46.	*Caenis simulans* McDunnough	CT — sb, sl
Family Baetiscidae		
47.	*Baetisca laurentina* McDunnough	MS
Family Ephemeridae		
48.	*Ephemera simulans* Walker	CT — mf, sb, sl
49.	*Hexagenia limbata* Walker	CT — mf, sb, sl

TABLE 1. *Continued*

50.	*Litobrancha recurvata* (Morgan)	AP — sb
PLECOPTERA		
Family Nemouridae		
51.	*Amphinemura linda* (Ricker)	NT — sb
52.	*Nemoura trispinosa* Claassen	NE — al, tr
53.	*Podmosta macdunnoughi* (Ricker)	NE — tr
54.	*Shipsa rotunda* Claassen	NT — al, tr
Family Taeniopterygidae		
55.	*Taeniopteryx parvula* Banks	MS
Family Capniidae		
56.	*Capnia vernalis* Newport	SH — mf
57.	*Paracapnia* sp.	
Family Leuctridae		
58.	*Leuctra ferruginea* Walker	MS — al, sb, tr
59.	*Leuctra tenella* Provancher	NE — al, sb, tr
60.	*Leuctra tenuis* Pictet	MS — al, sb, tr
61.	*Leuctra triloba* Claassen	AP
Family Pteronarcyiidae		
62.	*Pteronarcys dorsata* (Say)	NT — tr
Family Perlidae		
63.	*Paragnetina media* (Walker)	MS — sb, mf, tr
Family Perlodidae		
64.	*Cultus* cf. *aestivalis* (Needham & Claassen)	AP — mf
65.	*Isogenoides frontalis* (Newman)	SH
66.	*Isoperla bilineata* (Say)	SH
67.	*Isoperla cotta* Ricker	MS — sb
68.	*Isoperla frisoni* Illies	MS — al, sb, tr
69.	*Isoperla lata* Frison	MS — al, sb
70.	*Isoperla marlynia* (Needham & Claassen)	MS — al, sb
71.	*Isoperla transmarina* (Newman)	MS — al, sb, tr
Family Chloroperlidae		
72.	*Alloperla atlantica* Baumann	AP — al, sb, tr
TRICHOPTERA		
Family Rhyacophilidae		
73.	*Rhyacophila angelita* Banks	NTd
74.	*Rhyacophila brunnea* Banks	NTd — mt
75.	*Rhyacophila carolina* Banks	AP — al, sb, tr
76.	*Rhyacophila fuscula* (Walker)	MS — al, mf, mt, tr
77.	*Rhyacophila invaria* (Walker)	AP — al, tr
78.	*Rhyacophila minora* Banks	AP — tr
Family Glossosomatidae		
79.	*Glossosoma intermedium* (Klapalek)	HL/NT — mt
80.	*Glossosoma lividum* (Hagen)	NE — sl, tr
81.	*Glossosoma nigrior* Banks	MS — sb, sl
Family Philopotamidae		
82.	*Chimarra aterrima* Hagen	MS — al, mt, sb, tr
83.	*Dolophilodes distinctus* (Walker)	MS — al, mt, sb, tr
84.	*Wormaldia gabriella* (Banks)	CD
Family Psychomyidae		
85.	*Lype diversa* (Banks)	SH/MS — al, mt, sb, tr
Family Hyalopsychidae		
86.	*Phylocentropus lucidus* (Hagen)	MS
87.	*Phylocentropus placidus* (Banks)	MS — al, mt
Family Polycentropodidae		
88.	*Neureclipsis crepuscularis* (Walker)	SH/MS — al, mf, mt, sb, sl, tr
89.	*Neureclipsis valida* (Walker)	SH — sb, sl, tr
90.	*Nyctiophylax moestus* Banks	NT — mt, sb, sl
91.	*Polycentropus albipunctus* (Banks)	SH — sb, tr
92.	*Polycentropus aureolus* (Banks)	NT — sb
93.	*Polycentropus cinereus* Hagen	CT — al, sb, sl, tr
94.	*Polycentropus confusus* Hagen	MS — al, mt, sb, tr

TABLE 1. *Continued*

95.	*Polycentropus flavus* (Banks)	CT — sb, tr
96.	*Polycentropus iculus* Ross	SH — mt, sb, tr
97.	*Polycentropus pentus* Ross	MS — al, sb, tr
99.	*Polycentropus remotus* Banks	NT — sb, tr
100.	*Polycentropus smithae* Denning	NT — sb, tr
101.	*Polycentropus weedi* Morse & Blickle	NT — sb
Family Arctopsychidae		
102.	*Arctopsyche ladogensis* (Kolenati)	HL/NT — mt
Family Hydropsychidae		
103.	*Cheumatopsyche campyla* Ross	CT — al, sb, sl, tr
104.	*Cheumatopsyche gracilis*	CT — al, mt, sb, sl, tr
105.	*Cheumatopsyche pettiti* Banks	CT — al, sb, sl, tr
106.	*Cheumatopsyche speciosa* (Banks)	MS — sl, tr
107.	*Hydropsyche alhedra* Ross	MS — sb
108.	*Hydropsyche alternans* (Walker)	NT — al, mf, sb, tr
109.	*Hydropsyche betteni* Ross	MS — al, sb, tr
110.	*Hydropsyche bifida* Banks	CT — sb, sl
111.	*Hydropsyche confusa* (Walker)	NT — sl
112.	*Hydropsyche morosa* (Hagen)	MS — al, mt, sb, sl, tr
113.	*Hydropsyche slossonae* Banks	NT — sb
114.	*Hydropsyche sparna* Ross	MS — al, mt, sb, tr
115.	*Hydropsyche walkeri* Betten & Mosely	MS — mf, sb, sl, tr
116.	*Parapsyche apicalis* (Banks)	MS — al, sb, tr
Family Hydroptilidae		
117.	*Agraylea multipunctata* Curtis	HL/NT — sl
118.	*Hydroptila rono* Ross	CT
119.	*Hydroptila wyomia* Denning	SH — sb
120.	*Hydroptila xera* Ross	CT
121.	*Oxyethira aeola* Ross	CT
122.	*Oxyethira allagashensis* Blickle	NE
123.	*Oxyethira anabola* Blicke	NE —tr
124.	*Oxyethira araya* Ross	NE
125.	*Oxyethira grisea* Betten	NE — sb
126.	*Oxyethira michiganensis* Moseley	CT — sb
127.	*Oxyethira mirabilis* Morton	HL/NE
128.	*Oxyethira obtatus* Denning	NE
129.	*Oxyethira rivicola* Blickle & Morse	NE/AP — sb
130.	*Oxyethira serrata* Ross	NT — tr
131.	*Oxyethira zeronia* Ross	MS — sb
Family Phrygaeneidae		
132.	*Agrypnia colorata* (Milne)	NT
133.	*Agrypnia deflata* (Milne)	NT
134.	*Agrypnia glacialis* Hagen	NT
135.	*Agrypnia improba* (Hagen)	NT — mt, sb
136.	*Agrypnia macdunnoughi* (Milne)	NT
137.	*Agrypnia straminea* Hagen	NT — sb, sl, tr
138.	*Agrypnia vestita* (Walker)	MS — sb, sl, tr
139.	*Banksiola crotchi* Banks	NT — sb
140.	*Banksiola dossuaria* (Say)	NE — sb, sl
141.	*Beothukus complicatus* (Banks)	NE
142.	*Oligostomis ocelligera* (Walker)	MS? — tr
143.	*Oligostomis pardalis*	NE — mt
144.	*Phryganea cinerea* Walker	NT — mf, sb, tr
145.	*Ptilostomis semifasciata* (Say)	NT — mf, mt, sb, tr
Family Limnephilidae		
146.	*Anabolia bimaculata* (Walker)	CT — mf, mt, sb, tr
147.	*Anabolia consocia* (Walker)	MS — al, sb, tr
148.	*Anabolia sordida* Hagen	MS
149.	*Apatania nigra* (Walker)	NE — mf
150.	*Apatania stigmatella* (Zetterstedt)	HL/NT
151.	*Apatania zonella* (Zetterstedt)	HL/NT — sb
152.	*Arctopora pulchella* (Banks)	NTd — sb, tr

TABLE 1. *Continued*

153. *Asynarchus curtus* (Banks)	CT — mt, sb
154. *Chyrandra centralis* (Banks)	NTd — mt
155. *Glyphopsyche irrorata* (Fabricius)	NTd — mf, sb, sl
156. *Hesperophylax designatus* Banks	NE — mf
157. *Hydatophylax argus* (Harris)	NE — sb, tr
158. *Lenarchus crassus* (Banks)	NTd — sb
159. *Limnephilus argenteus* Banks	MS
160. *Limnephilus canadensis* Banks	SH
161. *Limnephilus externus* Hagen	HL/NT — sb
162. *Limnephilus extractus* Walker	MS — mf
163. *Limnephilus femoralis* Kirby	HL/NT
164. *Limnephilus hageni* Banks	NT
165. *Limnephilus indivisus* Walker	MS — mf, sb, sl, tr
166. *Limnephilus infernalis* (Banks)	CT — sb, sl, tr
167. *Limnephilus minusculus* (Banks)	CT
168. *Limnephilus moestus* Banks	NTd — mt, sb, sl, tr
169. *Limnephilus nimmoi* Roy & Harper	SH — tr
170. *Limnephilus ornatus* Banks	HL/NT — sb, sl, tr
171. *Limnephilus partitus* Walker	NT — mf
172. *Limnephilus parvulus* (Banks)	SH
173. *Limnephilus rhombicus* (Linné)	HL/NT — mf, sb, tr
174. *Limnephilus rossi* Leonard & Leonard	NE
175. *Limnephilus sericeus* (Say)	NTd — mf, sb, tr
176. *Limnephilus sublunatus* (Provancher)	CT — tr
177. *Nemotaulius hostilis* Hagen	CT — sb, sl, tr
178. *Neophylax aniqua* Ross	NE — sb
179. *Neophylax concinnus* MacLachlan	NE/AP — al, sb
180. *Neophylax nacatus* Denning	AP — met, sb, tr
181. *Neophylax oligius* Ross	NE — sb, tr
182. *Onocosmoecus unicolor* (Banks)	NT — mt, sb, tr
183. *Phanocoelia canadensis* (Banks)	SH
184. *Platycentropus amicus* (Hagen)	NE
185. *Platycentropus radiatus* (Say)	MS — sb, tr
186. *Psychoglypha subborealis* (Banks)	CT — sb
187. *Pycnopsyche guttifer* (Walker)	CT — al, mf, mt, sb, tr
188. *Pycnopsyche lepida* (Hagen)	MS — mf, mt, sb, sl, tr
189. *Pycnopsyche limbata* (Maclachlan)	NE sb, tr
Family Goeridae	
190. *Goera radissonica* Harper & Méthot	HL/NE
Family Leptoceridae	
191. *Ceraclea albosticta* (Hagen)	MS
192. *Ceraclea ancylus* (Vorhies)	MS — sb, sl, tr
193. *Ceraclea annulicornis* (Stephens)	HL/NT — sl, tr
194. *Ceraclea cancellata* (Betten)	MS — sb, tr
195. *Ceraclea diluta* (Hagen)	MS — al, sb, tr
196. *Ceraclea excisa* (Morton)	HL/NT
197. *Ceraclea resurgens* (Walker)	NT — mf, sb, sl, tr
198. *Ceraclea transversa* (Hagen)	MS — sb, sl
199. *Mystacides interjecta* (Banks)	NT — sb
200. *Mystacides sepulchralis* (Walker)	NT al, mf, sb, tr
201. *Nectopsyche albida* (Walker)	NT — mf, sl, tr
202. *Oecetis immobilis* (Hagen)	NT — sl
203. *Oecetis inconspicua* (Walker)	Ct — al, sb, sl, tr
204. *Oecetis nocturna* Ross	MS — sb, tr
205. *Setodes incertus* (Walker)	MS — mf, sb, tr
206. *Triaenodes baris* Ross	NT — sb, tr
Family Odontoceridae	
207. *Psilotreta indecisa* (Walker)	NE — mf, mt, sl, tr
Family Molannidae	
208. *Molanna blenda* Sibley	NE — sb
209. *Molanna flavicornis* Banks	NT — sl
210. *Molanna tryphena* Betten	NE — sb, tr

TABLE 1. *Concluded.*

211. *Molanna ulmerina* Navas	MS — sb, sl, tr
212. *Molanna uniophila* Vorhies	NE — sl
Family Lepidostomatidae	
213. *Lepidostoma costale* (Banks)	NE — al, sb, tr
214. *Lepidostoma modestum* (Banks)	NE
215. *Lepidostoma prominens* (Banks)	NE — mt, sb, tr
216. *Lepidostoma strophis* Ross	NT
217. *Lepidostoma swannanoa* Ross	AP — mt, sb, tr
218. *Lepidostoma togatum* (Hagen)	MS — mt, sb, sl, tr
219. *Lepidostoma unicolor* (Banks)	NT
Family Helicopsychidae	
220. *Helicopsyche borealis* (Hagen)	CT — sb, sl

trus fuliginosus Walker. Others include *Agrypnia pagetana* Curtis, *Limnephilus picturatus* McLachlan, and *Asynarchus lapponicus* Zetterstedt, all Holarctic species (Lehmkuhl and Kerst 1979), as well as *Limnephilus perpusillus* Walker and *Rhyacophila melita* Ross (Harper et al. 1975).

Discussion

As could be expected, the fauna presently inhabiting the west coast of the James Bay drainage is an assemblage of diverse elements of various origins. Their present coexistence depends on the geological and climatic history of the area and the dispersal patterns of the species.

Species richness

By comparison with the other sites studied in Québec and Ontario, the James Bay collections yielded a relatively large number of species. The inventory appears to have been more thorough in Trichoptera than in Plecoptera, where a long list of additional species were expected (Ricker et al. 1968) but not found. Perhaps this was due to the sampling scheme, but it is more likely caused by the absence of varied stonefly habitats in this rather low-altitude area.

The endemic element

As the territory under investigation is located in the middle of a huge glaciated area and far from any known refugium, an endemic element is unexpected. Indeed, both species of Trichoptera described as new from the area appear to be Holarctic (see above). *Caenis candida* Harper and Harper (1981) is the only remaining endemic element; it appears to be a valid species among North American taxa (A. Provonsha, personal communication) but it too may eventually prove to have a much wider distribution.

The Holarctic species

Three of the mayflies and 13 of the caddisflies but none of the stoneflies have Holarctic distributions. Relatively few North American mayflies have circumpolar distributions. The three recorded here are those which have the most extensive ranges in North America; other Holarctic species are restricted to the northwest in North America (e.g. *Baetis macani bundyae* Lehmkuhl, *Ephemerella mucronata* Bengtsson) or else they are more temperate (e.g. *Cloeon dipterum* (L.), *C. cognatum* Stephens). There are few Holarctic stoneflies and all (*Nemoura arctica* Esben-Petersen, *Diura bicaudata* (L.), *D. nanseni* (Kempny)) are either alpine or arctic. In the Trichoptera, dispersal seems to have been greater and this is reflected in the larger Holarctic element. This element is very characteristic of northern and arctic latitudes; its relative importance increases northward in most groups (Lehmkuhl and Kerst 1979; Scudder 1979; Danks 1981).

The transcontinental element

Nine mayflies, 3 stoneflies and 58 caddisflies have a more-or-less transcontinental distribution. These species are typically distributed across the northern half of the continent, but some mayflies (8) and caddisflies (20) have dispersed over virutally all of North America. This corresponds to the boreal element of Scudder (1979), deemed by him to be the most characteristic in the Canadian fauna.

The eastern element

The dominant element of the fauna (57% of mayflies, 71% of stoneflies and 47% of caddisflies), eastern species are typically centered around the Saint Lawrence drainage. One tenth of these species extend westwards to the Rockies and north into the Mackenzie drainage (SH), and one third are restricted to the eastern glaciated areas (NE).

The Appalachian element

Few (14) Appalachian species enter the study area. They are all inhabitants of small streams and they appear to reach in the James Bay area their northernmost geographical extension.

The central element

One species of mayfly, *Brachycercus prudens*, is distributed in the Central United States, and its presence in the study area was not anticipated. It represents a northward extension from a fauna normally confined to the upper Mississippi valley drainage. Such distributions are unusual because the Great Lakes and the surrounding lowlands seem to have been an insurmountable barrier for many organisms, especially lotic species. The fact that *Brachycercus* prefers lentic habitats may explain this exception.

The Cordilleran element

Two of the species, *Cultus* cf. *aestivalis* (Plecoptera) and *Wormaldia gabriella* (Trichoptera), have been identified as Cordilleran elements. The status of the former is uncertain. The typical distribution of *W. gabriella* being the Western ranges, its presence at James Bay represents a considerable extension to the East. Other species not recorded in this study have similar distributions; such are *Claassenia sabulosa* (Banks) in the Plecoptera (Ricker et al. 1968) and *Limnephilus picturatus* in the Trichoptera (Harper et al. 1975).

The arctic element

No truly arctic species were collected, these being restricted to the tundra ecosystem which lies northward. Such species would have included *Baetis macani bundyae* in the Ephemeroptera, *Capnia nearctica* and *Diura bicaudata* in the Plecoptera, and *Grensia praeterita* (Walker) and *Limnephilus pallens* Banks in the Trichoptera. Surprisingly, none of the these typical tundra dwellers occurs east of James Bay. All are restricted to the west of Hudson's Bay and may be supposed to have survived glaciations in the Northwestern refugium. Consequently, the tundra of Ungava is devoid of this element except for the endemic and still problematical *Capnia sugluka* Ricker (Ricker 1964). Since James Bay appears to act as a barrier to the dispersal of tundra forms, the eastern dispersal of arctic species must be rather recent: in earlier times colder climates would have provided a continuous band of tundra biotopes around the bays, though the presence of the Tyrrell Sea and, to lotic species at least, Lake Ojibway-Barlow might have hampered dispersal. That these species, at least in the Trichoptera, seem to be strictly associated with tundra conditions is shown by their presence at Rankin Inlet and their absnce from Churchill at the boreal forest border (Lehmkuhl and Kerst 1979); this does not seem to hold true for Plecoptera (Ricker 1964).

An overview

Table II summarizes much of the information and allows comparisons among the three orders. Three main elements can be recognized in the fauna: (1) Holarctic-transcontinental, (2) eastern, and (3) Appalachian, and the proportions of these vary considerably among the orders. There is a distinct gradient of increasing importance of element (1) from the Plecoptera to the Trichoptera, and a corresponding decrease in element (2).

The Holarctic-transcontinental element is richest in Trichoptera where it comprises just less than half of the fauna. Within this element, the Holarctic and the northern transcontinental groups predominate. In Ephemeroptera, the continental species are dominant, few of them being restricted to northern latitudes. In Plecoptera, the element is poorly represented. Such differences among the orders seem to reflect differences in dispersal potential, but other factors could be involved such as ecological valency. Nonetheless, the caddisflies combine good flight abilities, a long adult life, and relative hardiness,

TABLE 2. Distribution patterns in the Plecoptera (Pl), the Ephemeroptera (Ep), and the Trichoptera (Tr): number of species or units (some species occurring in two categories) in each category and percentages in major types. The last column (T) and the two last rows give totals of rows and columns respectively. Codes give distribution types: HL: Holarctic, NT: Northern Transcontinental, ds: discontinuous, CT: Continental, SH: Canadian Shield, NE: Northeastern, MS: Mississippian, CD: Cordilleran, CN: Central, AP: Appalachian, ED: Endemic.

	HL	NT	NTds	CT	SH	NE	MS	CD	CN	AP	ED	T
Pl	-	3	-	-	3	3	9	1	-	2	-	21
		14%				71.4%				9.5%		
Ep	3	1	-	8	1	10	16.5	-	1	6.5	1	48
		25%				57.3%				13.5%		
Tr	12	30	8	20	9	25	36	1	-	6	1	148
		47.3%				47.3%				4%		
	15	34	8	28	13	38	61.5	2	1	14.5	2	217
		39.2%				51.8%				6.7%		

factors that are conducive to high dispersal. The other groups lack such characteristics.

The eastern element follows the inverse gradient to the widely distributed elements, being greatest in Plecoptera and least in Trichoptera. In the three orders, about 50-60% of this element is typically distributed in the St. Lawrence/Mississippi drainages, the rest (25-36%) is restricted to the St. Lawrence and other northern drainages, and a minority of species (4-25%) extends westward to the foot of the Rockies.

The Appalachian element (4-13.5%) is poorly represented in the three orders, and surprisingly so in the Trichoptera. This cannot be due to a lack of dispersal ability of the adults. Perhaps as most of these species inhabit small spring-fed forest streams as larvae, their northward extension is hindered by the lack of such habitats.

Origins

The faunal composition is thus a blend of species with various distribution patterns and doubtless many dispersal routes. It is difficult to assess its origin from present patterns except by surmise.

Fifteen (7.4%) of the species are Holarctic and most of these seem to have western affinities. There is no evidence of any of them spreading from an Eastern refugium. *Utacapnia labradora* (Ricker), which was collected from the same drainage near Mistassini (Harper et al. 1975), could be a candidate for such an origin (Ricker 1964), but it did not show up in this series. There may be one amphi-Atlantic species: *Oxyethira mirabilis* fits the pattern, being distributed as well in northern Europe (Britain and Fennoscandia) where it is the only Old World representative of the *aeola* group of the subgenus *Oxytrichia*, which has radiated in the New World (Kelley 1984).

Of the 70 transcontinental species, 42 are mor or less restricted to the boreal zone. Many seem to have western affinities, though it is impossible to generalize. The two Cordilleran species could belong here, and actually be species gradually dispersing towards the east.

The eastern element must have survived glaciations south of the ice sheet and have migrated back with the retreating ice. Some species have been more successful than others and have reached as far as the Mackenzie drainage and the arctic coast.

The Appalachian element is thought to have migrated up and down the range with the ice movements and is characterized by a high level of endemism in the south and by species with high dispersal in the north. The species that have reached James Bay are among the more mobile. In Quebec, this element is most conspicuous in the east, and decreases markedly westwards.

Conclusion

Although this fauna shows few if any original elements, its composition is highly interesting. The extension of James Bay to the south into the boreal forest seems to act as a barrier for the eastwards dispersal of the species of western origin and, with the apparent lack of adequate refugia in the northeast, explains the relative poverty of the tundra and high arctic aquatic insect faunas of the Québec-Labrador peninsula in comparison with similar faunas from the Northwest territories. Rather, the habitats are taken over by the hardiest species of the eastern fauna.

The position of the sampling sites on the direct route of colonization of this region makes the fauna potentially one of the most interesting of middle latitudes in Québec. A similar course of dispersal seems to have been followed by freshwater fishes (Legendre and Legendre 1984).

However, so little is known of the fauna of the whole Nouveau-Québec area, that this systematic investigation of an aquatic insect fauna is but a first building block in understanding the biogeography of the aquatic insect fauna of northern Québec.

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Pintail, *Anas acuta*, Use of Man-made Ponds in Quebec

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Man-made ponds in south-central Québec were used by seven dabbling duck species of which the Northern Pintail (*Anas acuta*) was the most common, using all pond types studied. Mean Pintail brood density was 0.68/ha, with a maximum brood use of 2.7/ha at sewage ponds. Species that expanded their breeding ranges eastward during last decades like the Mallard (*Anas platyrhynchos*) and the Gadwall (*Anas strepera*) also made appreciable use of the man-made ponds (combined mean of 0.1 brood/ha). However, the study ponds were totally unattractive to broods of northeastern species such as the Wood Duck (*Aix sponsa*) or the Black Duck (*Anas rubripes*).

Key Words: Man-made ponds, dabbling ducks, broods, Pintail, *Anas acuta*, Québec.

Many duck species have greatly expanded their breeding ranges into eastern North America during recent decades, especially the Mallard (*Anas platyrhynchos*) (Johnsgard 1959) and the Gadwall (*Anas strepera*) (Henny and Holgersen 1974). The eastward spread of these species would have been favored by landscape transformation caused by deforestation, changes in agricultural practices, and urban development. Meanwhile, some northeastern waterfowl species have declined, particularly the Black Duck (*Anas rubripes*) (Rogers and Patterson 1984). Modifications in the availability or suitability of its natural breeding and wintering habitats, increase in hunting pressure, and competition or hybridization with the Mallard have all been mentioned as possible causes of its decline (Rogers and Patterson 1984).

Construction of ponds for ducks partially compensates for the loss of natural wetlands and maintains waterfowl populations (Uhler 1964). Knowledge of the use of these man-made habitats by breeding ducks and identification of the species that directly benefit from their creation are useful information for waterfowl managers. In another paper, we determined the overall brood use of various types of man-made ponds in southern Québec and we investigated pond features influencing the differential use observed (Bélanger and Couture 1988). Here, we examine the use of these man-made habitats by the different dabbling duck species, and discuss the possible role of artificial ponds in the distribution of breeding waterfowl in southern Québec.

Study Area and Methods

Surveys were conducted in the floodplain (2000 ha) of Lac Saint-Pierre, a natural widening (> 80 km^2) of the St. Lawrence River, 100 km east of Montréal. Twenty-nine shallow, permanent, man-made ponds were inventoried, all located less than 3 km from the main marsh of the lake, except for one sewage pond 5 km inland. Mean distance between ponds varied from 50 to 4000 m. Ponds were classified into sewage ponds (N = 3), sand-pit ponds (N = 6), annular ponds (N = 10) and excavated ponds (N = 10). Detailed biophysical description of these man-made pond types was presented by Bélanger and Couture (1988). Terrestrial plant communities were dominated by different species of willow (*Salix* sp.), Reed Canarygrass (*Phalaris arundinacea*) and Bluejoint (*Calamagrostis canadensis*). Most abundant aquatic plants were Broad-leaved Cattail (*Typha latifolia*), Common Arrowhead (*Sagittaria latifolia*), Canadian Waterweed (*Elodea canadensis*) and Whitish Watermilfoil (*Myriophyllum exalbescens*). Maple groves or wet meadows adjoined annular and excavated ponds whereas agricultural lands surrounded sewage and sand-pit ponds. All ponds had a rectangular basin shape with stands of shrubs or trees along their irregular shorelines. Mean surface area of sewage and sand-pit ponds was 1.5 ha compared to an average of 0.2 ha for annular and excavated ponds.

Waterfowl broods were censused from natural blinds on the shores of each pond from May through the beginning of August during 1982 and 1983. Ponds were censused 1/2 h before sunrise or after sunset for an average of 2.5 times/year. A third census was conducted on ponds where broods were observed during at least one of the two previous censuses. Species identification was based upon the accompanying females. Unidentified broods (mean 15% of all broods observed during the two years) were excluded from this study, and we assumed that these were evenly distributed in each species.

Data analysis was conducted following Scherrer (1984) and performed on the SAS package. The Shapiro-Wilk statistic test was used to verify the normal distribution of variables. The Kruskal-Wallis test followed by the Multiple Comparisons Test proposed by Noether (1976, *in* Scherrer 1984: 541) was used to determine differences in duck densities among species. The acceptable level of statistical significance was established at 0.05 throughout the data analysis.

Results

Forty dabbling duck broods and 247 ducklings were observed. Pintails (*Anas acuta*) far outnumbered any other species, representing 64% of all broods recorded. Mallards (14%), Northern Shovelers (*Anas clypeata*) (10%) and Gadwalls (6%) were also common, whereas Blue-winged Teals (*Anas discors*), American Wigeons (*Anas americana*) and Black Ducks accounted for less than 2% each. No Green-winged Teal (*Anas crecca*) or Wood Duck (*Aix sponsa*) broods were observed, but adults of both species occurred in the study area. No diving duck broods were also recorded, although adult Ring-necked Ducks (*Aythya collaris*) and Lesser Scaups (*Aythya affinis*) have been observed in early spring in sewage and sand-pit ponds.

Pintail broods occurred in higher densities (0.68/ha) than broods of other species (0.38/ha) ($P < 0.0001$; Table 1). No differences in brood density were detected, however, among the remaining species ($P > 0.05$; Table 1). Brood use differed between years; densities were higher in 1982 than in 1983 for all species ($P < 0.05$). Mean number of ducklings/brood was different among species ($P < 0.05$; Table 1); it was higher for Gadwall and Wigeon but did not differ among others ($P > 0.05$; Table 1). Species diversity was higher in sewage and sand-pit ponds than in the two other types ($P < 0.01$). The Pintail was the only species found in all habitats, although sewage ponds were used significantly more often by this species ($P < 0.05$). Broods of all other species occurred exclusively on sewage ponds, except for Mallard and Blue-winged Teal also recorded in excavated and sand-pit ponds, respectively.

TABLE 1. Use of man-made ponds by broods of different dabbling duck species in Québec, 1982-1983. N = 40 broods.

	Brood Use	
Species	Broods/ha X SE	Ducklings/brood[a] X SE
Mallard	0.15 ± 0.11 B	5.4 ± 1.9 B
Black Duck	0.02 ± 0.02 B	6.0 ± 0.0 B
Gadwall	0.05 ± 0.05 B	11.7 ± 0.3 A
Northern Pintail	0.68 ± 0.25 A	5.9 ± 0.6 B
Blue-winged Teal	0.04 ± 0.03 B	4.3 ± 1.8 B
American Wigeon	0.02 ± 0.02 B	10.0 ± 0.0 A
Northern Shoveler	0.10 ± 0.06 B	5.5 ± 0.5 B

[a] All age-classes combined.

[b] Column entries without the same letter are significantly different ($P < 0.05$).

Discussion

Many studies have documented brood use of different types of man-made ponds both by dabbling and diving ducks in the prairie and central regions (Lokemoen 1973; Swanson 1977; Hudson 1983), but similar data from northeastern North America is scarce. In our study, seven species of Anatini were recorded, and the Pintail was by far the most abundant, accounting for 60% of all broods observed. This can be explained by a combination of different factors: (1) the Pintail is one of the most abundant dabbling duck species in the surrounding natural marshes of Lac Saint-Pierre (Lehoux et al. 1985); and (2) the Pintail is known to be a pioneering species of newly created or improved habitats (Hochbaum and Bossenmaeir 1971). The intensive use of sewage ponds by Pintail broods as well as by all other species can be attributed to their exceptional biological productivity. Bélanger and Couture (1988) reported that benthic and emergent plant densities were considerably higher in these sewage ponds (means of $345/m^2$ and $30/m^2$, respectively) than in other man-made pond types studied (combined means of $69/m^2$ and $18/m^2$). Sewage ponds have also been found to be used intensively by breeding waterfowl elsewhere (Swanson 1977; Piest and Sowls 1985). The differential use of man-made pond types by broods as observed in our study is discussed elsewhere (Bélanger and Couture 1988).

Broods of species newly expanded eastward such as the Gadwall and the Mallard made significant use of the man-made ponds studied. Changes in landscape, deforestation and modification or intensification of agricultural practices have favoured a recent invasion of the Mallard into the East (Johnsgard 1959; Heusmann 1974). This species is recognized as a generalist in terms of habitat use, and many studies have reported its use of man-made ponds such as stormwater control impoundments (Adams et al. 1985), stock ponds (Lokemoen 1973) and sewage ponds (Piest and Sowls 1985). The Gadwall is another western species that recently expanded its breeding range eastward (Henny and Holgersen 1974). For example, although the first record of Gadwall breeding in Québec was only in 1962 (Cantin et al. 1976), this species is now one of the most important in hunter bags, particularly in the southwestern region of the province (Lehoux et al. 1985). Cantin et al. (1976) mentioned that the creation of artificial islands with dredged materials from the St. Lawrence Seaway provided an ideal nesting and breeding habitat for this species (stable water level, abundant nesting cover, low predation and human disturbance pressures) that had facilitated its invasion into Québec. Henny and Holgersen (1974) also stated that the creation of man-made habitats (reservoirs) in many National Wildlife Refuges of the United States led to the Gadwall increase in the Northeast.

The man-made ponds censused in this study were, however, totally unattractive to northeastern species, such as the Black Duck, a species or color morph (*see* Ankney et al. 1986) that has declined in Ontario and southern Québec since the mid-1960s (Rogers and Patterson 1984). Even excavated ponds that present a more forest aspect because of their proximity to maple groves, with bushy shores and low level of biological productivity (Bélanger and Couture 1988), were not attractive to Black Ducks although deciduous flooded forested habitats are generally highly selected by this species (Ringelman et al. 1982). Creation of man-made ponds in our study area do not seem to promote this species. No Green-winged Teal or Wood Duck broods were recorded in our study, although both species have been shown to use man-made ponds elsewhere (Wenner and Marion 1981; Piest and Sowls 1985). The presence of nesting boxes at the periphery of most of the excavated ponds, a well-known successful management technique for the Wood Duck (Belrose and McGilvrey 1966), did not attract this species.

In conclusion, our results indicate that (1) Pintail were the most abundant species of ducks using the four types of man-made ponds studied, (2) sewage ponds were the only type used by all duck species censused and, (3) man-made ponds were unattractive to northeastern duck species such as the Black Duck or the Wood Duck. Therefore, as suggested by Heusmann (1974) and Henry and Holgersen (1973), the creation of man-made ponds in eastern North America, in addition to other landscape transformations, may have created a string of potentially productive breeding habitats (farm ponds, agricultural ditches, sewage ponds, etc.), unattractive or inadequate for northeastern species, have favoured the invasion of prairie duck species. A more detailed and comparative study of the breeding duck use of adjacent man-made and natural habitats in the same area is needed, however, to verify this general hypothesis.

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Vascular Plant Flora of the Wager Bay Region, District of Keewatin, Northwest Territories

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Cody, W. J., G. W. Scotter, and S. C. Zoltai. 1989. Vascular plant flora of the Wager Bay Region, District of Keewatin, Northwest Territories. Canadian Field-Naturalist 103(4): 551–559.

One hundred and thirteen species of vascular plants are reported from the Wager Bay region as a result of field surveys of 21 localities in 1984. Phytogeographic affinities of this flora are: 83 circumpolar; 3 amphi-Beringian, 10 amphi-Atlantic and 17 North American endemics. *Pleuropogon sabinei* is a new record for the Continental Northwest Territories.

Key Words: Vascular plants, Wager Bay, District of Keewatin, Northwest Territories.

Wager Bay is located in the northeastern section of the District of Keewatin between latitudes 65° and 66° N and longitudes 87° and 91° W. A natural resource survey of the region was undertaken by the Canadian Wildlife Service and Canadian Forestry Service during 1984 because of its potential as a possible new national park. The vascular plant flora of the Wager Bay region was virtually unknown. Only a few vascular plants had been recorded from the region and these were limited to the coastal area (Porsild and Cody 1980). The purpose of this paper is to report the plants collected during the 1984 survey.

Study Area

The study area includes the drainage basin of Wager Bay, an area of approximately 19 500 km^2, (excluding the bay itself). It is a long inlet from Roes Welcome Sound opposite Southampton Island, extending inland in a northwest by west direction some 200 km. The abandoned settlement of Wager Bay is located at the narrow westerly end of the inlet. The entire area is underlain by Precambrian granitoid gneiss, migmatite and granodiorite (Heywood 1967). This bedrock surface has been modified by glaciers, leaving large areas of exposed bedrock and deposits of thin, bouldery till. In some areas, such as north of Wager Bay, deep sandy till occurs in low drumlins. In post-glacial times, marine intrusion affected the coastal areas lying below the present 130-m contour (Zoltai et al. 1987), eroding the inundated areas, but depositing little or no marine sediments.

The study area lies within the Wager Plateau (Bostock 1970), a broad, bedrock dominated peneplain that rises up to 600 m asl (above sea level). In some areas, rugged bedrock topography prevails, where the soil is only found on lower slopes or in valleys. Low, gently undulating till plains occur especially near the watershed divide, often interrupted by gravelly eskers. Low, wave-scoured bedrock hills dominate the lowlands close to Wager and Hudson bays. Permafrost underlies all land surfaces and only the top 30-90 cm are thawed during the brief summer. A large number of lakes occur throughout the area, mostly in rockbound basins. They are connected by short watercourses that ultimately drain into Wager Bay.

The climate is characterized by long, cold winters and low amounts of precipitation. The frost-free period is about 68 days (Newbury et al. 1979), but frost can occur even during the summer months. The total precipitation is about 230 mm annually, about half of which occurs as snow. Strong winds are prevalent especially during the fall to spring period (Zoltai et al. 1987).

The vegetation is typical of the Low Arctic tundra (Zoltai et al. 1987), with variations due to soil depth, texture and drainage. The well-drained, deeper soils have a continuous cover of low shrub-heath vegetation, with dwarf, ground-hugging shrubs, sedges and saxicolous lichens. Mosses increase on the moister sites, but the incidence of lichens decreases. The wet sites are dominated by sedges and cottongrass, as well as mosses. The extensive bedrock and rock rubble areas are covered by crustose and umbilicate lichens, with only scattered dwarf shrubs and mosses.

Methods

The survey was carried out during five days (6 to 10 August 1984) with heliocopter support. This allowed CWS and SCZ to examine a range of habitats including situations that had been covered by late snow patches. In all, a total of 113 species of vascular plants were collected from the area and this is considered to be a reasonably complete list.

Because most of these represented new localities for the species as shown in the maps presented in Porsild and Cody (1980), comments are presented in the list which follows by reference to those maps. In addition to the vascular plants, collections of mosses and lichens were also made. These specimens have been submitted to authorities on these groups and the information gained from them may be included in broader treatments of those groups.

Study Sites

In the course of the survey, 21 sites were studied (Figure 1). Data on collection localities is summarized below:

1. 65°39′N, 88°48′W, 0-45 m, 6 August 1984. Variable:
    a. Bare granitic bedrock, with plants in fissures.
    b. Well drained sandy beach, scattered vegetation.
    c. Wet meadow around small lake, with *Carex*-moss association.
2. 65°23′N, 88°15′W, 0-6 m, 6 August 1984.
    a. Exposed granitic bedrock.
    b. Small pockets of wet meadows with *Carex*-moss association.
3. 65°03′N, 88°28′W, 265 m, 6 August 1984. Rock rubble and well-drained till. *Alectoria* and ericads.
4. 65°01′N, 88°49′W, 210 m, 6 August 1984. Dry sandplain. *Alectoria* and some grasses.
5. 65°17′N, 89°13′W, 265 m, 6 August 1984. Imperfectly drained till, with ericads, moss and lichens.
6. 65°36′N, 88°16′W, 210 m, 7 August 1984.
    a. Imperfectly drained till on a long, gentle slope, with *Carex*, moss, ericads.
    b. Poorly drained low-center polygons with *Carex*-moss association.
7. 65°47′N, 88°27′W, 225-240 m, 7 August 1984. Imperfectly drained till on a gentle slope, with *Carex*-moss association.
8. 65°40′N, 88°34′W, 90 m, 7 August 1984. Well-drained till slopes and exposed bedrock with heather-lichen vegetation.
9. 65°43′N, 88°52′W, 5-30 m, 7 August 1984. Variable:
    a. South-facing rock cliff.
    b. Well-drained sand plain, with *Alectoria* and some grass.
    c. Wet tundra meadows with *Carex*-moss association.
10. 65°55′N, 89°25′W, 90 m, 7 August 1984. Exposed bedrock and rock rubble, patches of heather-lichen tundra.
11. 66°02′N, 89°46′W, 35 m, 7 August 1984. Well-drained till slope with heather-lichen association and imperfectly drained till meadows with *Carex*-moss association.
12. 65°56′N, 90°49′W, 0-10 m, 7 August 1984. Gently sloping, imperfectly drained till slope. Disturbance around human settlement.
13. 65°53′N, 90°09′W, 30 m, 7 August 1984.
    a. Beach ridge of well-drained sand, with some *Alectoria*.
    b. Wet meadow with pools, low-center polygons: *Carex*-moss.
14. 65°33′N, 89°43′W, 365 m, 9 August 1984. Gentle slope of stony, imperfectly drained till with lichen and *Cassiope*.
15. 65°57′N, 91°01′W, 60 m, 9 August 1984. Well-drained sand plain, with lichen and some grass.
16. 66°21′N, 91°53′W, 185 m, 9 August 1984. Sloping esker, well to imperfectly drained gravel, with *Cladonia* and *Cassiope*.
17. 65°59′N, 91°37′W, 90 m, 9 August 1984. Well-drained till on SW slope, with heather and lichen.
18. 65°55′N, 91°23′W, 40-52 m, 9 August 1984. Lakeshore; imperfectly drained sand, with *Carex*-moss.
19. 65°59′N, 91°00′W, 90 m, 9 August 1984. Well-drained sand plain, with *Alectoria*-grass.
20. 65°20′N, 87°25′W, 25-30 m, 10 August 1984. Low hillocks of exposed bedrock, with moist spots. Scattered plant cover.
21. 65°16′N, 88°07′W, 45 m, 10 August 1984.
    a. Moist marine silt plain with *Dryas*.
    b. Sloping bedrock ridge.

Annotated Species List

In the list of vascular plants which follows, the collection numbers are those of GWS. The locality number is given in parentheses following the collection number. The voucher collections have been deposited in the herbarium of the Biosystematics Research Centre, Agriculture Canada, Ottawa (DAO). The taxonomy follows Porsild and Cody (1980) unless otherwise stated. Common names for the most part follow those in Porsild and Cody (1980) or Anderson (1959). In addition to the distribution maps published in Porsild and Cody (1980), which depict the known ranges to that time in the continental Northwest Territories, the authors consulted the more detailed, larger scale manuscript maps of A. E. Porsild on which those published were based.

POLYPODIACEAE

Cystopteris fragilis (L.) Bernh., Fragile Fern, *76123* (2). Circumpolar arctic-alpine; not previously known from the mainland part of northern District of Keewatin (Porsild and Cody 1980).

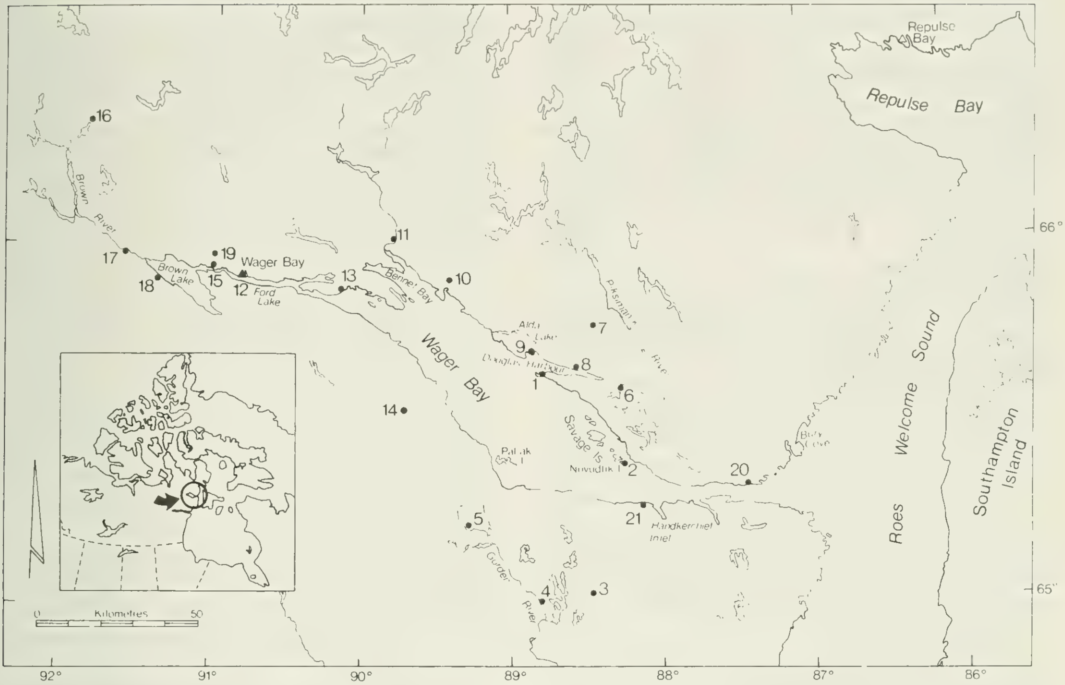

FIGURE 1. Locations of survey sites in the Wager Bay region, Northwest Territories. Inset locates region in northern Canada.

Dryopteris fragrans (L.) Schott., Fragrant Shield Fern, *76129* (2); *76177* (9); *76226* (12); *76244* (17); *76262* (21). Circumpolar, arctic-alpine; not previously known from the Wager Bay area (Porsild and Cody 1980).

EQUISETACEAE

Equisetum scirpoides Michx., Dwarf Scouring-rush, *76261* (20). Circumpolar, low-arctic; this collection from near the mouth of the Bay extends the known distribution some 240 km north and east from sites mapped by Porsild and Cody (1980).

LYCOPODIACEAE

Lycopodium selago L., Mountain Club-moss, *76140* (5). Circumpolar, wide-ranging high arctic-alpine; the nearest site mapped by Porsild and Cody (1980) was at the mouth of the Bay.

GRAMINEAE

Arctagrostis latifolia (R. Br.) Griseb., *76003* (1); *76133* (3); *76184* (9); *76202*(11); *76222* (12). Circumpolar, arctic-alpine; not previously known from the inland parts of the Bay.

Calamagrostis stricta (Timm.) Koeler (*C. neglecta* (Ehrh.) Gaertn., Mey. & Scherb.), Reed Bentgrass, *76145*(16), *76166* (8); *76211* (11); *76214*, *76218*, *76221* (12); *76245* (18). Circumpolar; not previously recorded from the area adjacent to Wager Bay.

Dupontia fisheri R. Br. ssp. *psilosantha* (Rupr.) Hultén, *76044*, *76050* (1); *76195*(9). Circumpolar, low-arctic; the nearest site mapped by Porsild and Cody (1980) was at the mouth of the Bay.

Elymus arenarius L. ssp. *mollis* (Trin.) Hultén, Sea Lyme Grass, *76041* (1). Circumpolar, low-arctic; this collection from near the head of the Bay is midway between a site near the Arctic Circle to the north and a site on the coast of Hudson Bay some 200 km to the south.

Festuca brachyphylla Schultes, Alpine Fescue, *76004*, *76015*, *76033*, *76039*, *76043*, *76046* (1); *76107B* (2); *76213*, *76219* (12). Circumpolar, high-arctic-alpine; the nearest site mapped by Porsild and Cody (1980) was at mouth of the Bay.

Hierochloe alpina (Sw.) R. & S., Holy Grass, *76048* (1), *76106* (2); *76136* (4); *76154* (7). Circumpolar, arctic-alpine; these collections are midway between a site near the Arctic Circle to the north and a site on the coast of Hudson Bay some 200 km to the south.

Phippsia algida (Sol.) R. Br., *76217* (12). Circumpolar, high-arctic; this is only the third known site in mainland District of Keewatin, the other two being adjacent to the 100° W longitude.

Pleuropogon sabinei R. Br., Semaphore Grass, *76049* (1). A high-arctic species reported as amphi-Atlantic by Hultén (1958) and since demonstrated to be circumpolar in distribution (Hultén and Fries 1986). The species is new to the flora of the Continental Northwest Territories (Porsild and Cody 1980) on the basis of the collection cited here. The nearest known sites are in northern Southampton Island and southern Melville Peninsula about 150 km to the east and northeast respectively.

Poa alpigena (Fr.) Lindm., Blue Grass, *76040* (1); *76183* (9). Circumpolar, arctic-alpine; the nearest site depicted by Porsild and Cody (1980) was at the mouth of the Bay.

Poa arctica R. Br., Arctic Blue Grass, *76047* (1); *76126* (2); *76181*, *76185* (9). Circumpolar, arctic-alpine; the nearest site mapped by Porsild and Cody (1980) was at the mouth of the Bay.

Poa glauca M. Vahl, Glaucous Blue Grass, *76045* (1); *76171* (9); *76223* (12); *76240* (17). Circumpolar, arctic-alpine; these collections are midway between a site near the Arctic Circle to the north and a site on the coast of Hudson Bay some 200 km to the south.

Puccinellia langeana (Berl.) Th. Sor., Goose Grass, *76034*, *76038*, *76042* (1); *76215*; *76216* (12). North American, low-arctic; previous collections from mainland District of Keewatin were all from the Hudson Bay coast (Porsild and Cody 1980).

Puccinellia phryganodes (Trin.) Scribn. & Merr., Goose Grass, *76035* (1). Circumpolar, arctic; the only mainland District of Keewatin site plotted by Porsild and Cody (1980) was from the Hudson Bay coast just south of the mouth of Wager Bay.

Trisetum spicatum (L.) Richt. s.l., *71607*A (2); *76193* (9). Circumpolar, arctic-alpine; the nearest site plotted by Porsild and Cody (1980) was near the mouth of the Bay.

CYPERACEAE

Carex aquatilis Wahlenb. var. *stans* (Drej.) Boott, Water Sedge, *76137* (5); *76236*(15). Circumpolar, arctic; not previously recorded from the inland parts of the Bay.

Carex bicolor All., Two-colour Sedge, *76023*, *76028* (1). Circumpolar, low-arctic; this is an extension of the known range in the District of Keewatin of some 240 km northward from a site on the Hudson Bay coast (Porsild and Cody 1980).

Carex bigelowii Torr., Bigelow Sedge, *76006*, *76010* (1). Amphi-Atlantic, arctic; the nearest sites in the District of Keewatin are from coastal Hudson Bay some 200 km to the south and on southern Southampton Island.

Carex capillaris L. s.l., Hair-like Sedge, *76013*, *76016*, *76021*, *76025* (1). Circumpolar, arctic-alpine; in northeastern District of Keewatin, the nearest known site is some 125 km to the south on the coast of Hudson Bay.

Carex chordorrhiza L.f., Creeping Sedge, *76009*, *76146* (1); *76257* (20). Circumpolar, low-arctic; this is an extension of the known range of some 200 km north from a coastal Hudson Bay site plotted by Porsild and Cody (1980).

Carex glaresosa Wahlenb. var. *amphigena* Fern., Sedge, *76019* (1); *76220* (12). Circumpolar, arctic; the nearest site plotted by Porsild and Cody (1980) was at the mouth of the Bay.

Carex maritima Gunn., Seaside Sedge, *76024* (1). Circumpolar, arctic; a site plotted by Porsild and Cody (1980) in Central District of Keewatin was in error, other sites plotted for the District were all coastal.

Carex membranacea Hook., Fragile Sedge, *70014* (1); *76138*, *76139* (5); *76236B* (15). North America west to eastern Siberia, arctic; not previously recorded from the inland part of the Bay (Porsild and Cody 1980).

Carex misandra R. Br., Short-leaved Sedge, *76008*, *76104A* (1); *76160* (7); *76238* (17). Circumpolar, high-arctic-alpine; not previously recorded from the inland parts of the Bay (Porsild and Cody 1980).

Carex nardina Fr. var. *atriceps* Kuk., Sedge, *76248* (19). Amphi-Atlantic; the nearest sites plotted by Porsild and Cody (1980) were from near the Arctic Circle to the north and some 200 km to the south on coastal Hudson Bay.

Carex norvegica Retz., Norway Sedge, *76011*, *76030*, (1); *76153* (7). Amphi-Atlantic; this is the northernmost site yet recorded in the District of Keewatin and represents an extension of the known range of some 160 km from a coastal Hudson Bay site plotted by Porsild and Cody (1980).

Carex rariflora (Wahlenb.) Sm., Loose-flowered Alpine Sedge, *76020* (1); *76199* (10); *76207* (11). Circumpolar, low-arctic; these sites are midway between a coastal Hudson Bay site some 240 km to the south and a site near the Arctic coast on longitude 90° W (Porsild and Cody 1980).

Carex scirpoidea Michx., Northern Single-spike Sedge, *76029* (1); *76164* (8). North American; not previously recorded from the inland parts of the Bay (Porsild and Cody 1980).

Carex vaginata Tausch, Sheathed Sedge, *76155* (7); *76235* (15). Circumpolar, not previously recorded from the inland parts of the Bay (Porsild and Cody 1980).

Eleocharis acicularis (L.) R. & S., Needle Spike-rush, *76036* (1). Circumpolar, subarctic; this is a northeasterly extension of the known range of some 240 km from a Hudson Bay shore site mapped by Porsild and Cody (1980).

Eriophorum angustifolium Honck., Tall or Narrow-leaved Cotton-grass, *76134* (3); *76141B*

(5); 76176(9). Circumpolar, low-arctic; in northeastern District of Keewatin not previously recorded from the area between the Arctic Circle to the north and a coastal Hudson Bay site some 200 km to the south (Porsild and Cody 1980).

Eriophorum callitrix Cham., Arctic Cotton-grass, *76144* (6); *76225* (12). Circumpolar, arctic-alpine; apparently not a frequent species in mainland District of Keewatin where it has not previously been recorded in the area between the Arctic Circle to the north of Wager Bay and a coastal site some 150 km to the south (Porsild and Cody 1980).

Eriophorum russeolum Fr. var. *albidum* Nyl., Russet Cotton-grass, *76141A* (5); 76142(6). Circumpolar, low-arctic; not previously recorded from the area between the Arctic Circle to the north and a coastal Hudson Bay site about 200 km to the south (Porsild and Cody 1980).

Eriophorum scheuchzeri Hoppe, White Cotton-grass, *76017*, *76018* (1); *76208* (11). Circumpolar, arctic-alpine; the map in Porsild and Cody (1980) indicates only four sites in continental District of Keewatin, the nearest to Wager Bay adjacent to the Arctic Circle to the north, and about 125 km to the south on the coast of Hudson Bay.

Kobresia simpliciuscula (Wahlenb.) Mack., *76022* (1). Circumpolar, arctic-alpine; not previously recorded from the area between the Arctic Circle to the north and a coastal Hudson Bay site about 200 km to the south (Porsild and Cody 1980).

Scirpus caespitosus L. ssp. *austriacus* (Pallas) Asch. & Graeb., Tufted Bulrush, *76032*(1). Circumpolar, low-arctic; this is an extension of the known range in mainland District of Keewatin of some 500 km to the east from a site near longitude 100° W (Porsild and Cody 1980).

JUNCACEAE

Juncus albescens (Lange) Fern., Bog-rush, *76247* (18). North America, arctic-alpine; previous collections in mainland northern District of Keewatin have all been along the Hudson Bay coast, the nearest at the mouth of Wager Bay, some 200 km to the east of the present collection (Porsild and Cody 1980).

Juncus biglumis L., Bog-rush, *76007* (1). Circumpolar, high-arctic-alpine; this site at Douglas Harbour is midway between a site on the Arctic Circle to the north and one on the Hudson Bay coast some 200 km to the south (Porsild and Cody 1980).

Juncus castaneus Smith, Chestnut Bog-rush, *76026*, *76031* (1). Circumpolar, arctic-alpine; this site at Douglas Harbour is midway between a site on the Arctic Circle and one on the Hudson Bay coast some 170 km to the south.

Luzula confusa Lindebl., Northern Wood-rush, *76012*, *76027*, *76037* (1); *76150* (6); *76194* (9). Circumpolar arctic-alpine; the nearest site mapped by Porsild and Cody (1980) was at the mouth of the Bay.

Luzula wahlenbergii Rupr., Wood-rush, *76152* (7); *76237* (16). Circumpolar, low-arctic; these sites adjacent to Wager Bay are midway between a site on southern Melville Peninsula to the north and one on the Hudson Bay coast some 250 km to the south (Porsild and Cody 1980).

LILIACEAE

Tofieldia coccinea Richards., False Asphodel, *76170* (8). North American arctic-alpine west to central-east Asia; this collection helps fill in a large gap in the known distribution between sites on Baffin Island some 650 km to the east and western District of Keewatin some 500 km to the west (Porsild and Cody 1980).

Tofieldia pusilla (Michx.) Pers., False Asphodel, *76224* (12); *76260* (20). Circumpolar, arctic-alpine; these sites are midway between one on southern Melville Peninsula to the north, and one on coastal Hudson Bay about 150 km to the south (Porsild and Cody 1980).

SALICACEAE

Salix alaxensis (Anderss.) Cov., Alaska Willow, *76100B*(1); *76165* (8). Amphi-Beringian; these sites are midway between a site on southern Melville Peninsula to the north, and one on coastal Hudson Bay about 240 km to the south (Porsild and Cody 1980).

Salix arctica Pall., Arctic Willow, *76056*, *76100A*, *76102*, *76103* (1); *76119*(2); *76167* (8); *76243* (17); *76259* (20). Circumpolar, arctic-alpine; these sites are midway between a site at the base of Melville Peninsula to the north and a site on coastal Hudson Bay some 150 km to the south.

Salix fuscescens Anderss., Willow, *76148* (6). Amphi-Beringian, arctic-alpine; this is an extension of the known range of some 250 km to the north from Chesterfield Inlet; the dot on the map in Porsild and Cody (1980) at the mouth of Wager Bay was incorrectly placed, being based on specimens collected by D. B. O. Savile at Chesterfield Inlet according to a notation on Porsild's working maps.

Salix herbacea L., Least Willow, *76094* (1); *76115* (2); *76147* (6); *76196* (9). Amphi-Atlantic, low-arctic; these collections are midway between a site on southern Melville Peninsula and a site on coastal Hudson Bay some 250 km to the southeast (Porsild and Cody 1980).

Salix reticulata L., Net-veined Willow, *76156* (7); *76258* (20). Circumpolar, arctic-alpine; these collections help complete the known distribution in northeastern District of Keewatin between Chesterfield Inlet to the south and the Arctic Coast to the north (Porsild and Cody 1980).

BETULACEAE

Betula glandulosa Michx., Dwarf Birch, *76149* (6). North American, boreal and sub-arctic; these collections are from the most northeasterly locations in the District of Keewatin yet known, a distance of 250 km from the vicinity of Chesterfield Inlet (Porsild and Cody 1980).

POLYGONACEAE

Koenigia islandica L., *76058*, *76105* (1). Circumpolar, arctic-alpine; not previously recorded from the vicinity of Wager Bay but known from an inland site some 150 km to the west and from near Chesterfield Inlet (Porsild and Cody 1980).

Oxyria digyna (L.) Hill, Mountain Sorrel, *76172* (9). Circumpolar, arctic-alpine; the nearest site mapped by Porsild and Cody (1980) was at the mouth of Wager Bay.

Polygonum viviparum L., Alpine Bistort, *76082* (1); *76151* (7). Circumpolar, arctic-alpine; in the northeastern part of mainland District of Keewatin the nearest known sites are from near Chesterfield Inlet and a site some 400 km to the west (Porsild and Cody 1980).

CARYOPHYLLACEAE

Cerastium alpinum L., Alpine Chickweed, *76080* (1); *76178* (9); *76203* (11). Amphi-Atlantic, arctic; midway between a site in southern Melville Peninsula and a site on coastal Hudson Bay some 150 km to the south (Porsild and Cody 1980).

Honckenya peploides (L.) Ehrh. var. *diffusa* (Hornem.) Mattf., Seabeach-Sandwort, *76057* (1). Circumpolar low-arctic; midway between a site near the Arctic Circle and a site on the coast of Hudson Bay some 150 km to the south.

Melandrium apetalum (L.) Fenzl ssp. *arcticum* (Fr.) Hultén, Bladder-Campion, *76088* (1); *76116* (2). Circumpolar, high-arctic; the nearest sites plotted by Porsild and Cody (1980) are at Coral Harbour on Southampton Island, on the Hudson Bay coast about 150 km to the south and on the Arctic Coast.

Minuartia rubella (Wahlenb.) Hiern., Northern Sandwort, *76092* (1). Circumpolar, arctic-alpine; only five sites are plotted by Porsild and Cody (1980) for mainland District of Keewatin, the nearest sites being on eastern Melville Peninsula, eastern Southampton Island and on coastal Hudson Bay some 150 km to the south.

Sagina caespitosa (J. Vahl) Lge., Cushion Pearlwort, *76093* (1). Amphi-Atlantic, arctic; this is a northward extension of the known range from sites plotted by Porsild and Cody (1980) at Coral Harbour, Southampton Island and in central District of Keewatin.

Silene acaulis L., Moss Campion, *76071* (1). Circumpolar, arctic-alpine; midway between sites on eastern Melville Peninsula, southern Southampton Island and the Hudson Bay coast some 150 km to the south plotted by Porsild and Cody (1980).

Stellaria crassipes Hultén, Chickweed, *76055B*, *76090* (1). Amphi-Atlantic, arctic; midway between sites plotted by Porsild and Cody (1980) on eastern Melville Peninsula, Southampton Island and coastal Hudson Bay some 125 km to south.

Stellaria laeta Richards., Chickweed, *76055A*, *76089* (1); *76190* (9). North America, arctic; the nearest site plotted by Porsild and Cody (1980) is just north of the mouth of the Bay.

Stellaria longipes Goldie., Long-stalked Chickweed, *76162* (8). North American, non-arctic; this is an extension of the known range given by Porsild and Cody (1980) from south-central District of Keewatin.

Stellaria monantha Hultén, Chickweed, *76051* (1); *76173* (9); *76191* (9); *76201*(11). North American, arctic-alpine; also at the mouth of the Bay (Porsild and Cody 1980).

RANUNCULACEAE

Ranunculus hyperboreus Rottb., Arctic Buttercup, *76099* (1). Circumpolar, arctic-alpine; midway between sites on the Arctic Coast, southern Southampton Island and the Hudson Bay coast some 150 km to the south (Porsild and Cody 1980).

Ranunculus pedatifidus Sm. var. *leiocarpus* (Trautv.) Fern., Northern Buttercup, *76113*(2). Circumpolar arctic-alpine; also near the mouth of the Bay (Porsild and Cody 1980) .

Ranunculus pygmaeus Wahlenb., Dwarf Buttercup, *76186* (9). Circumpolar, arctic-alpine; the nearest known sites are in southern Melville Peninsula, southern Southampton Island and central southern District of Keewatin (Porsild and Cody 1980).

PAPAVERACEAE

Papaver radicatum Rottb., Arctic Poppy, *76067* (1); *76241* (17). Circumpolar, arctic-alpine; midway between sites on southern Melville Peninsula, southern Southampton Island and coastal Hudson Bay some 125 km to the south (Porsild and Cody 1980).

CRUCIFERAE

Cardamine bellidifolia L., Alpine Bitter Cress, *76064* (1); *76163* (8); *76234* (14); *76256* (20). Circumpolar, arctic-alpine; midway between sites on eastern Melville Peninsula, the Arctic coast, southern Southampton Island and coastal Hudson Bay some 150 km to the south (Porsild and Cody 1980).

Cochlearia officinalis L. s.l., Scurvy-grass, *76083* (1). Circumpolar; the nearest previously known site for this halophyte was just south of the mouth of the Bay (Porsild and Cody 1980).

Draba glabella Pursh, *76108* (2). Circumpolar, arctic-alpine; midway between a site at the base of Melville Peninsula and a coastal Hudson Bay site some 150 km to the south (Porsild and Cody 1980).

Draba lactea Adams, *76263*, *76264* (21). Circumpolar, high-arctic; also at the mouth of Wager Bay (Porsild and Cody 1980).

Draba nivalis Liljebl., *76122* (2); *76250* (19). Circumpolar, arctic-alpine; midway between a site at the base of Melville Peninsula and a coastal Hudson Bay site some 150 km to the south (Porsild and Cody 1980).

Eutrema edwardsii R. Br., *76210* (11). Circumpolar, arctic; midway between a site at the base of Melville Peninsula, several sites on Southampton Island, and a coastal Hudson Bay site some 150 km to the south (Porsild and Cody 1980).

SAXIFRAGACEAE

Saxifraga caespitosa L. s.l., Tufted Saxifrage, *76068* (1); *76118*, *76127* (2). Circumpolar, arctic-alpine; also near the mouth of Wager Bay (Porsild and Cody 1980).

Saxifraga cernua L., Nodding Saxifrage, *76101* (1); *76120* (2). Circumpolar, arctic-alpine; midway between a site in southern Melville Peninsula and a coastal Hudson Bay site some 150 km to the south (Porsild and Cody 1980).

Saxifraga foliolosa R. Br., Foliose Saxifrage, *76005*, *76052*, *76069* (1); *76128* (2). Circumpolar, high-arctic; the nearest site depicted by Porsild and Cody (1980) is about 80 km to the south on the coast of Roes Welcome Sound.

Saxifraga hirculus L. s.l., Marsh Saxifrage, *76073* (1). Circumpolar, arctic-alpine; midway between a site near the Arctic Circle, sites on Southampton Island and a site on the Hudson Bay coast about 150 km to the south (Porsild and Cody 1980).

Saxifraga nivalis L., Alpine Saxifrage, *76086* (1); *76192* (9); *76239* (17). Circumpolar, arctic; Porsild and Cody (1980) depict a site just inside the Bay.

Saxifraga oppositifolia L., Purple Saxifrage, *76070* (1). Circumpolar, arctic-alpine; Porsild and Cody (1980) show the nearest site just north of the mouth of the Bay.

Saxifraga rivularis L. s.l., Brook Saxifrage, *76095* (1); *76188*, *76189* (9); *76230*(13). Circumpolar, arctic-alpine; Porsild and Cody (1980) record a site near the mouth of Wager Bay.

Saxifraga tricuspidata Rottb., Prickly Saxifrage, *76074*, *76079* (1); *76121*(2). North American, arctic-alpine; also present at sites on the south side of the Bay and just north of the entrance to the Bay (Porsild and Cody 1980).

ROSACEAE

Dryas integrifolia M. Vahl, Mountain Avens, *76060* (1). North American, arctic-alpine; midway between a site near the Arctic Circle and a site on the Hudson Bay coast about 150 km to the south (Porsild and Cody 1980).

Potentilla hyparctica Malte var. *elatior* (Abrom.) Fern., Cinquefoil, *76085*, *76096*, *76104* (1); *76180* (9); *76242* (17). Circumpolar, low-arctic; midway between sites on the east side of Melville Peninsula, the Arctic Coast and Hudson Bay coast about 150 km to the south (Porsild and Cody 1980).

Potentilla palustris (L.) Scop., Marsh Cinquefoil, *76143* (6). Circumpolar; in mainland District of Keewatin an extension of the known range of some 150 km from a site south of the mouth of Chesterfield Inlet (Porsild and Cody 1980).

Potentilla vahliana Lehm., Cinquefoil, *76249* (19); *76254* (20). North American, high-arctic; midway between sites on southern Melville Peninsula and a coastal Hudson Bay site about 150 km to the south.

LEGUMINOSAE

Astragalus alpinus L., Alpine Milk-vetch, *76061*, *76062* (1); *76233* (13). Circumpolar, arctic-subarctic-alpine; midway between a site on southern Melville Peninsula, sites on Southampton Island and a coastal Hudson Bay site some 150 km to the south (Porsild and Cody 1980).

Oxytropis maydelliana Trautv., Oxytrope, *76072*, *76077* (1); *76112* (2); *76161*(8); *76179*, *76198* (9); *76200*, *76205* (11); *76265*, *76266* (21). North American, eastern arctic; Porsild and Cody (1980) depict a site on the south side of Wager Bay.

EMPETRACEAE

Empetrum nigrum L. var. *hermaphroditum* (Lge.) Bocher, Crowberry, *76059* (1). Circumpolar; Porsild and Cody (1980) depict a site near the mouth of Wager Bay.

ONAGRACEAE

Epilobium latifolium L., Broad-leaved Willowherb, *76078* (1). Circumpolar, arctic-alpine; also near the mouth of Wager Bay (Porsild and Cody 1980).

HOLORAGACEAE

Hippuris vulgaris L., Mare's-tail, *76054* (1). Circumpolar; Porsild and Cody (1980) depict a site on the Roes Welcome Sound coast south of Wager Bay.

PYROLACEAE

Pyrola grandiflora Radius, Large-flowered Wintergreen, *76206* (11). Circumpolar, arctic-alpine; the nearest known sites are on the east side of Melville Peninsula, Coral Harbour on Southampton Island and on coastal Hudson Bay about 150 km to the south (Porsild and Cody 1980).

ERICACEAE

Andromeda polifolia L., Andromeda or Bog Rosemary, *76175* (9). Circumpolar; this is an extension of the known range to the northeast of about 150 km from a site on the Hudson Bay coast (Porsild and Cody 1980).

Arctostaphylos alpina (L.) Spreng., Alpine Bear Berry, *76091* (1); *76124* (2); *76251* (19); *76268* (21). Circumpolar, arctic; midway between a site on the east side of Melville Peninsula and a site near the entrance of Roes Welcome Sound to the south (Porsild and Cody 1980).

Cassiope tetragona (L.) D. Don, Arctic White Heather, *76081* (1); *76131* (3); *76232* (13). Circumpolar, arctic; Porsild and Cody (1980) depict a site in central Wager Bay area.

Ledum decumbens (Ait.) Lodd., Narrow-leaved Labrador-tea, *76084* (1); *76132* (3); *76231* (13). North America to eastern Siberia, arctic; midway between sites on southern Melville Peninsula, eastern Southampton Island and coastal Hudson Bay some 150 km to the south (Porsild and Cody 1980).

Rhododendron lapponicum (L.) Wahlenb., Lapland Rose-bay, *76168* (8). Circumpolar, arctic-alpine; Porsild and Cody (1980) depict a site in the central Wager Bay area.

Vaccinium uliginosum L. ssp. *alpinum* (Bigel.) Hultén, Bilberry, *76159* (7). Circumpolar; midway between sites on southern Melville Peninsula, southern Southampton Island and southern mainland District of Keewatin (Porsild and Cody 1980).

Vaccinium vitis-idaea L. var. *minus* Lodd., Mountain Cranberry, *76065* (1); *76130* (3). Circumpolar, subarctic-arctic; Porsild and Cody (1980) depict a site near the mouth of Wager Bay.

DIAPENSIACEAE

Diapensia lapponica L., *76169* (8); *76229* (13). Amphi-Atlantic, arctic-alpine; midway between southern Melville Peninsula, Coral Harbour on Southampton Island and coastal Hudson Bay some 150 km to the south (Porsild and Cody 1980).

PLUMBAGINACEAE

Armeria maritima (Mill.) Willd. ssp. *labradorica* (Wallr.) Hultén, Thrift or Sea Pink, *76097*(1); *76109* (2). Amphi-Atlantic, arctic; midway between southern Melville Peninsula, Coral Harbour on Southampton Island and coastal Hudson Bay some 150 km to the south (Porsild and Cody 1980).

BORAGINACEAE

Mertensia maritima (L.) S. F. Gray, Sea Lungwort, *76066* (1); *76114* (2). Amphi-Atlantic; Porsild and Cody (1980) depict a site for this halophyte near the mouth of Wager Bay.

SCROPHULARIACEAE

Pedicularis labradorica Wirsing, Labrador Lousewort, *76204*, *76212* (11). Circumpolar, subarctic-alpine; this is a northeastward extension of the known range of some 400 km from a site on coastal Hudson Bay (Porsild and Cody 1980).

Pedicularis sudetica Willd., Lousewort, *76076*, *76087* (1); *76157*, *76158* (7); *76174* (9). Circumpolar, arctic-alpine; midway between sites at the base of Melville Peninsula, on Southampton Island and on coastal Hudson Bay some 150 km to the south (Porsild and Cody 1980).

CAMPANULACEAE

Campanula uniflora L., Arctic Harebell or Bellflower, *76267* (21). Circumpolar, high-arctic-alpine; Porsild and Cody (1980) depict a site near the mouth of Wager Bay.

COMPOSITAE

Antennaria angustata Greene, Pussy's-toes, *76063* (1); *76111* (2); *76209* (11); *76228* (13). North American, arctic-subarctic-alpine; Porsild and Cody (1980) depict a site at the east end of Wager Bay.

Antennaria canescens (Lge.) Malte, Pussy's-toes, *76182* (9). North American, subarctic; this is an extension of the known range of some 400 km to the northeast from a site in south central District of Keewatin (Porsild and Cody 1980).

Artemisia borealis Pall., Northern Wormwood, *76252* (20). Circumpolar, subarctic; midway between a site near the Arctic Circle and a site on coastal Hudson Bay about 150 km to the south (Porsild and Cody 1980).

Chrysanthemum integrifolium Richards., Mountain Daisy, *76255* (20). North American, arctic-alpine; this is a southward extension of the known range of some 150 km from a site at the base of Melville Peninsula near the Arctic Circle (Porsild and Cody 1980).

Erigeron humilis Grah., Mountain Fleabane *76125* (2); *76253* (20). Circumpolar, arctic-alpine; midway between sites in southern Melville Peninsula, central District of Keewatin to the southwest and coastal Hudson Bay some 150 km to the south (Porsild and Cody 1980).

Taraxacum lacerum Greene, Dandelion, *76098* (1); *76110* (2); *76197* (9). North American, arctic-subarctic; midway between a site near the Arctic Circle to the north and a site on the Hudson Bay coast about 150 km to the south (Porsild and Cody 1980).

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Winter Habitat and Browse Use by Snowshoe Hares, *Lepus americanus*, in a Marginal Habitat in Pennsylvania

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We examined habitat and woody browse use by Snowshoe Hares (*Lepus americanus*) in Pennsylvania northern hardwood clearcut stands during winter. Resident hares were found only in successfully regenerated stands, which contained higher seedling and sapling densities and more cover (e.g., stumps, slash) than unsuccessfully regenerated stands. Habitat use was positively correlated to several variables, including abundance of seedlings and saplings of all species combined and distance to slash piles. Conversely, habitat use was negatively related to abundance of tall (≥ 1.5 m) raspberry (*Rubus* spp.) and distance to other clearcut stands. Hares browsed 3.4% of the available woody twigs, feeding principally on *Rubus* spp., Striped Maple(*Acer pensylvanicum*), and Yellow Birch (*Betula alleghaniensis*). Although these stands are near the southern extent of the geographic range of Snowshoe Hares and probably represent marginal habitat for the species, habitat and browse use by hares in our study were not unlike that reported for hares elsewhere.

Key Words: Snowshoe Hare, *Lepus americanus*, clearcut stands, habitat, browse, Pennsylvania.

Snowshoe Hares (*Lepus americanus*) are common to northern boreal forests of North America, with populations extending south into higher elevations of the Rocky and Appalachian Mountains (Hall 1981; Carreker 1985). Many studies have dealt with hare populations occupying northern coniferous forests (e.g., Brocke 1975; Pietz and Tester 1983; Litvaitis et al. 1985), whereas relatively few have been conducted on populations in deciduous forests near the southern extent of their range (e.g., Dolbeer and Clark 1975; Sievert and Keith 1985). Information on habitat and browse use by Snowshoe Hares in southern and/or marginal habitats would provide important insight into the ecology and management of this species across its geographic range. habitat and browse use by Snowshoe Hares in northern hardwood clearcut stands have not been published to our knowledge. Our objective in the present study was to determine winter habitat and browse use by Snowshoe Hares in Pennsylvania northern hardwood clearcut stands, which likely represent a suitable but perhaps marginal habitat for Snowshoe Hares in southern latitudes.

Study Area and Methods

The study was conducted on International (Hammermill) Paper Company lands (tract Potter 18), Potter Co., Pennsylvania, in the Black Cherry (*Prunus serotina*) — maple (*Acer* spp.) northern hardwood group (Marquis 1980). Six of 25 representative clearcut stands were selected for intensive study of habitat and browse use by hares in winter 1984-1985 according to percent successful regeneration, species composition, age, and size. The remaining 19 stands were visited once in winter 1984-1985 after a recent snowfall to search for evidence of hares (e.g., tracks, pellets). All stands were classified as successfully or unsuccessfully regenerated (hereafter termed successful and unsuccessful, respectively). A successful stand had at least 70% of 20 randomly selected regeneration plots (1.83-m radius) with two or more stems of desirable species ≥ 1.5-m tall (Marquis and Bjorkbom 1982). Of the six stands selected for intensive study, three were successful and three were unsuccessful. Of the 19 stands examined for hare evidence, 11 were successful and eight were unsuccessful. Desirable species included Black Cherry, Red Maple (*Acer rubrum*), and Sugar Maple (*Acer saccharum*), White Ash (*Fraxinus americana*), North America Tuliptree (*Liriodendron tulipifera*), Cucumber-tree Magnolia (*Magnolia acuminata*), Northern Red Oak (*Quercus rubra*), and Yellow Birch. The six stands were located on ridgetops, were logged between 1968 and 1978, and ranged from 9.1 to 20.2 ha in size. Each stand was surrounded by mature, northern hardwood forest.

Four 500-m transects were established in each of the six stands, with two in a 50-m wide edge zone and two in the center zone. Each transect was divided into 50-m linear sampling units. A trap station was placed in the middle of each unit, giving 40 trap stations per stand. Hares were captured in each stand during two, 10-day periods

(N = 2400 total trapnights) from mid-January to early April 1985 using collapsible, single-door Tomahawk live-traps (90 × 30 × 30 cm) baited with alfalfa and apples. Hares were marked with numbered, color-coded ear tags and numbered hindfoot tags. Sex, age (juvenile or adult), weight (g), hindfoot length (mm), and reproductive condition were recorded (Keith et al. 1968). A trap index was calculated for each 50-m sampling unit based on the total number of captures at a given trap station, where 1 = a trap station with one or more hare captures and 0 = a trap station with no captures.

Five or six track counts were made in each clearcut stand approximately 24 hours after a snowfall from January-early April 1985. The total number of tracks crossing or parallel (within 5 m) to each 50-m sampling unit were counted (modified from Conroy et al. 1979). In addition, the first trail or runway encountered in each 50-m sampling unit was followed for 5 m on either side of a transect to determine the presence of activity loci, which were either woody twigs browsed by hares or diurnal forms used by hares. The mean number of tracks and activity loci were summed to derive a track index for each 50-m sampling unit.

We counted fecal pellets after snowmelt in each clearcut stand in late April 1985. A 0.5-m radius plot was located 2 m from the center of each trap station in the four cardinal directions. The total number of pellets in the four plots was used to derive a pellet index for each 50-m sampling unit. Associations between activity indices (trap, track, and pellet) per sampling unit and regeneration status (successful, unsuccessful) of the stand containing a given unit were determined by *G* tests-of-independence (Sokal and Rohlf 1981).

Habitat variables were measured at each trap station from June to mid-August 1985 (Swihart and Yahner 1982; *see details in* Scott 1986). These included numbers of slash piles (> 1-m^2), fallen logs (> 1-m long, ≥ 7.5-cm diameter), stumps (> 25-cm tall, and > 7.5-cm diameter), and overstory trees (woody stem > 1.5-m tall, ≥ 7.5-cm dbh) per species and all species combined in a 0.04-ha circular plot centered on a trap station; numbers of overstory trees and saplings (woody stem > 1.5-m tall, < 7.5-cm dbh) per species and all species combined in two, perpendicular 1-m wide transects centered on a trap station; numbers of seedlings (woody stems < 1.5-m tall) in two, 1-m radius plots located 2 m north and east of the center of a trap station; canopy height (m) above a trap station; canopy coverage (%) taken from 20 ocular tube sightings along the two 1-m wide transects at a trap station; and distances (m) to the nearest slash pile, fallen log, stump, overstory tree, seedling or sapling clump (> 10 stems/m^2), coniferous stand, and clearcut stand from a trap station.

Relationships between habitat variables and activity indices per 50-m sampling unit were examined using stepwise multiple regression (SAS, Inc. 1982) and logistic regression (BMDPLR: Engelman 1985). *P*-to-enter and remove for both types of regression analyses was 0.05.

Browse use by hares was quantified in May 1985 along five randomly selected transects in each stand. Eight, 1-m radius plots were established at 10-m intervals along each transect, giving 40 plots per stand. Within each plot, number of total twigs (browsed and unbrowsed), number of twigs browsed by hares, and diameter at point of browsing were recorded by woody species at 0-60 and 61-120 cm above mean snowdepth (23.8 cm in winter 1984-1985) (Keith et al. 1984). A twig was defined as any portion of a woody plant less than or equal to 10 mm in diameter.

Goodness-of-fit *G*-tests (Sokal and Rohlf 1981) were used to test if use of all woody browse species in a stand was as expected based on availability. Differences in expected use were determined by chi-square tests-of-independence after cells were collapsed around the species of interest (Pearre 1982).

Results

We captured 12 Snowshoe Hares 48 times, and 40 (83%) of these captures were in the three successful stands. Based on 40 plots in each of the six stands, 75 to 88% had tracks and 70 to 73% had pellets in successful stands. In contrast, 0 to 38% had tracks and 8 to 20% had pellets in unsuccessful stands. Activity indices (trap, track, and pellet) were significantly ($P < 0.05$) higher in successful than in unsuccessful stands (Scott 1986). In the additional 19 stands examined for evidence of hares, tracks and/or pellets were found in nine stands; eight of these stands were classified as successful.

Habitat use based on the trap index was positively correlated with number of both seedlings and saplings, canopy height, and distance to slash (chi-square = 60.2, d.f. = 4; $P < 0.001$). The track index was positively correlated with numbers of Pin Cherry (*Prunus pensylvanica*) seedlings, saplings of all species combined, and Black Cherry overstory trees, and was negatively correlated with number of *Rubus* spp. and distance to the nearest clearcut stand ($R = 0.47$, $F = 40.7$, d.f. = 5, $P < 0.0001$). The pellet index was positively correlated with canopy height, and numbers of stumps, Black Cherry and Pin Cherry seedlings, saplings of all species combined, Black Cherry overstory trees, and was negatively related to distance to the nearest stand ($R = 0.42$, $F = 23.7$, d.f. = 7,232; $P < 0.0001$). Additional details of regression models are presented in Scott (1986).

Hares browsed only within the 0-60 cm stratum, using between 0.5 and 10.3% of the available twigs per stand in this stratum. We found that *Rubus* spp., Striped Maple, and Yellow Birch were used significantly more than expected in all stands, and American Beech (*Fagus grandifolia*), Pin Cherry, Black Cherry, Red Maple, and Sugar Maple were used significantly less than expected.

Discussion

Although coniferous stands generally are considered optimal habitat for Snowshoe Hares (e.g., Brocke 1975), successfully regenerated northern hardwood clearcut stands apparently represent important habitats for hares in southern latitudes with limited coniferous cover, as in Pennsylvania. Certain features of hardwood stands, such as high seedling and sapling densities, provided both food and cover for hares. Slash also may be important as shelter for hares from inclement weather or from predators (Aldous 1937; *but see* Conroy et al. 1979). Despite *Rubus* spp. being a preferred browse species, hares tended to avoid areas in stands with high densities of *Rubus* spp., presumably because these areas had little or no canopy cover and potentially greater predation risks (Dolbeer and Clark 1975; Buehler and Keith 1982; Wolfe et al. 1982).

Hares occurred in clearcut stands that were close (< 0.5 km) to other clearcut stands. These nearby clearcut stands probably were important to hares by providing alternate sources of food and cover throughout the year. Seasonal shifts in habitat use by hares in response to changes in food and cover have been noted in other geographical regions (Adams 1959; Wolff 1980). Thus, future population increases and geographic range expansion of hares in Pennsylvania may be contingent on the availability of suitable, nearby habitat (Sievert and Keith 1985).

Woody browse use by hares during winter in our study (e.g., *Rubus* spp., Striped Maple, and Yellow Birch) was similar to that noted for hares in northern hardwood stands in northwestern Pennsylvania (Brown 1984). Therefore, low densities of hares likely have a negligible effect on regeneration of desirable timber species in northern hardwood stands.

Extensive browse use by White-tailed Deer (*Odocoileus virginianus*) may have important negative consequences to the successful establishment of Snowshoe Hares in northern hardwoods. For example, introduced hares did not become established on release sites in central Pennsylvania where deer browsing was pronounced (Glazer 1959). Elimination of potential hare food and cover resources by high deer populations may be a major factor influencing range expansion by hares of previously occupied habitat and contribute to its status as a species of special concern in Pennsylvania (Dalby 1985).

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Sand-spurreys, *Spergularia* spp., in Saskatchewan, Including the First Inland Record for *S. canadensis* var. *occidentalis*

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Harms, Vernon L. 1989. Sand-spurreys, *Spergularia* spp., in Saskatchewan, including the first inland record for *S. canadensis* var. *occidentalis*. Canadian Field–Naturalist 103(4): 564–571.

A study was conducted to elucidate the taxonomy, variation and distribution of the sand-spurreys (*Spergularia* spp.) in Saskatchewan, based on field collections and herbarium specimen records. Most frequent and widespread in the province is *Spergularia marina* L. var. *leiosperma* (Kindb.) Guerke, while *S. marina* var. *marina* is less frequent and more northeastern in distribution. A rare naturalized species, recorded from only four localities in western Saskatchewan, is *S. diandra*. *Spergularia canadensis* (Pers.) G. Don var. *occidentalis* R.P. Rossbach is first reported as a surprising new species record for Saskatchewan, and as the first known inland station for the species.

Key Words: Saskatchewan, sand-spurreys, *Spergularia canadensis* var. *occidentalis, Spergularia diandra, Spergularia marina* var. *marina* and *leiosperma*, maritime halophytes.

The sand-spurreys (*Spergularia* spp., in Family Caryophyllaceae) have generally been considered uncommon if not actually rare plants in the flora of Saskatchewan and adjacent regions (e.g. Lowe 1943; Breitung 1957; Looman and Best 1979; Stevens 1950; Booth and Wright 1959; McGregor and Barkley 1977). Earlier collections from Saskatchewan and the adjacent provinces and states often were variously referred to *S. salina* J. & C. Presl, *S. sparsiflora* (Greene) A. Nels., *S. leiosperma* (Kindb.) Fern., and *S. rubra* A. Nels. (Rydberg 1932; Fraser and Russell 1937, 1944, 1954; Lowe 1943; Stevens 1950). Since Rossbach's (1940) revisionary monograph of *Spergularia* in North and South America, most authors of flora-manuals have followed her treatment, submerging *S. salina, S. sparsiflora* and *S. leiosperma* as synonyms under the species, *S. marina* (L.) Griseb., either taxonomically separated or not into var. *leiosperma* (Kindb.) Guerke and var. *marina,* based on the absence versus presence of glandular papillae on the seed surfaces, respectively. Rossbach (1940) and authors of more recent checklists and flora-manuals have excluded *S. rubra* for Saskatchewan and adjacent areas of the northern Great Plains (Breitung 1957; Scoggan 1957; Moss 1959; Boivin 1968; Scoggan 1978; Looman and Best 1979; Packer 1983; Larson 1986). While Rossbach (1940), in her text, did not accord formal taxonomic recognition to the varieties *leiosperma* and *marina* under *S. marina*, she separately cited and mapped the "smooth-" and "papillose-seeded" plants. For Saskatchewan, Rossbach listed only the smooth-seeded variant (= var. *leiosperma*) at three localities. Wood Buffalo Park in northeastern Alberta was included among her very few inland stations in North America for the papillose-seeded variant (= var. *marina*). Subsequently Breitung (1957), Moss (1959), Looman and Best (1979), and Packer (1983) considered only the variety *leiosperma* as occurring in Saskatchewan or Alberta. Moss (1959) and Packer (1983) also recorded *S. diandra* (Guss.) Boiss. in southeastern Alberta. Boivin (1966, 1968) included only *S. marina* s. lato for the Canadian Prairie Provinces, not distinguishing varieties, and even merging *S. diandra* with it. Scoggan (1978) listed Saskatchewan within the Western Canadian range of *S. marina* var. *leiosperma*, and presumably also included the province within his generalized continental range for the typical var. *marina.* He reported *S. diandra* in western Canada "from B.C. . . . and from SE Alta.", referring to "Moss (1959)" for the latter. Larson (1986) reported only the species, *S. marina* (without any varietal distinctions) for the Northern Great Plains from "scattered locations in North Dakota".

Although sand-spurreys have not been frequently collected, today the recorded Saskatchewan sites of *Spergularia* collections in herbaria have increased nearly ten-fold from the five localities cited in the annotated provincial lists by Fraser and Russell (1944) and Breitung (1957). Thus we have a somewhat better specimen-base available today for attempting to elucidate the taxonomy, variation, and distribution of Saskatchewan's sand-spurreys (*Spergularia* spp.)

A personal review of the available herbarium collections from Saskatchewan (in SASK, DAO, CAN, SCS and USAS; acronyms following Holmgren et al. 1981) revealed the occurrence of three sand-spurrey species, — viz. *Spergularia marina, S. diandra,* and quite surprisingly, *S.*

canadensis (Pers.) G. Don var. *occidentalis* R. P. Rossbach. Within *S. marina,* both the smooth-seeded var. *leiosperma* and the papillose-seeded var. *marina,* are found in the province.

The distribution map of Figure 1 was constructed, showing the known occurrences of the various *Spergularia* taxa in Saskatchewan, based upon the herbarium specimens personally seen, verified, and cited below.

Key to *Spergularia* Species in Saskatchewan

The *Spergularia* species in Saskatchewan may be distinguished by using the following taxonomic key:

1a. Seeds larger, (0.8-) 0.9-1.2 (-1.4) mm long, their surfaces smoothish, not glandular-papillose, medium- to dark-brown, mostly with distinct wings 0.3-0.5 mm wide; leaf apex broadly acute, thin-foliar, not mucronate; petals 2.5 mm long or less; styles 0.3-0.4 mm long. .... 3. *S. canadensis* var. *occidentalis.*

1b. Seeds smaller, 0.8 mm long or less, their surfaces either smooth or papillose, either tawny to chestnut-brown or black, wingless or only rarely with weak erose wings that are less than 0.3 mm wide; leaf apex mucronate, with a ± distinct, short callus-mucro; petals 1.6-4.0 mm long; styles 0.4-0.6 mm long. .... (to 2).

2a. Mature seeds pyriform, small, 0.5 mm long or less, never winged, black with a silvery tinge ± distinctly rugulose-sculptured, and with scattered blackish glandular-papillae present or not; stipules of young shoots to 2 mm long, connate only at base for much less than half their length; petals usually white (rarely slightly pinkish); stamens 4-7; capsules almost globose, shorter, mostly 2.5-4 mm long, equalling to only slightly exceeding the calyx length; leaves to 2.5 cm long and 1.0 mm wide; plants smaller, more often prostrate, the main stems and lower branches less than 1.5 dm long. .... 2. *S. diandra.*

2b. Mature seeds sub-reniform, mostly larger, 0.5-0.8 mm long, wingless or rarely winged, tawny (at least peripherally) to often chestnut-brown in center, not rugulose-sculptured, with light-brown glandular-papillae present or not; stipules connate for about half their length to appear sheathing; petals mauve or roseate to pinkish (or sometimes white); stamens 2-5; capsules mostly ellipsoid, 3.5-6 mm long, subequal to usually much exceeding the calyx; leaves often somewhat longer and wider, to 3(3-4) cm long and 1.5 mm wide; plants often larger, the main stems and lower branches to 3.5 dm long. .... 1. *S. marina.*

Species Accounts

1. *Spergularia marina* (L.) Griseb. — Salt-marsh Sand-spurrey; Sea-spurrey.

This is an apparently native species characteristic of initially moist to later drying, saline or alkaline, ± sandy flats, depressions, slough bottoms, marsh-edges, very shallow-water marshes, shores, and dry salt-lake beds. The monographer, Rossbach (1940), and most authors of North American floras have accepted *S. marina* as indigenous at least in western North America and probably also along the Atlantic, Gulf of Mexico and Hudson Bay coasts, although perhaps introduced where found at more inland localities in eastern North America. Gleason and Cronquist (1963), and more recently Voss (1985) and Larson (1986), however, considered that the species may have been introduced and naturalized in North America from Eurasia. While always difficult to assess the native vs. naturalized status of a species from its known occurrences in only a limited region, based on its distribution and habitats in Saskatchewan, there would seem no reason to question the indigenous nature of *S. marina* here. Unlike the obviously "artificial" habitats (e.g. highway de-icing salt drainages, snow-dumps, salt-storage depots, etc.) reported for the species at inland locations in southern Ontario and Michigan (Catling and McKay 1980; Voss 1985), all known Saskatchewan collections appear to be from quite natural and relatively undisturbed habitats. Most of the halophytic assemblages on sandy or marshy shores of saline lakes, sloughs, valley marshes, and wet alkaline meadows where *S. marina* occurs, contain few introduced weedy species even when in relatively close proximity to agricultural lands and roadsides.

Both taxonomic varieties of *S. marina*, separated essentially on the presence vs. absence of glandular-papillae on the seed surfaces (see Figure 2), may be recognized in Saskatchewan. Habitat differences between the two varieties are not obvious. Some botanists, including Rossbach (1940) herself, have considered these to represent only minor variants or forms. The infrequency of mixed collections in Saskatchewan (only 3; see Figure 1), and the tendency for variety *marina* to be more northern in distribution, suggest, at least to this author, that a varietal separation of the respective taxa is tenable. Also, despite the disclaimer of this character by Rossbach (1940) and its subsequent omission from the keys and descriptions in most recent flora-manuals, the positive correlation between papillose seeds and shorter middle and upper floral bracts, reported many years ago by Fernald and Wiegand (1910),

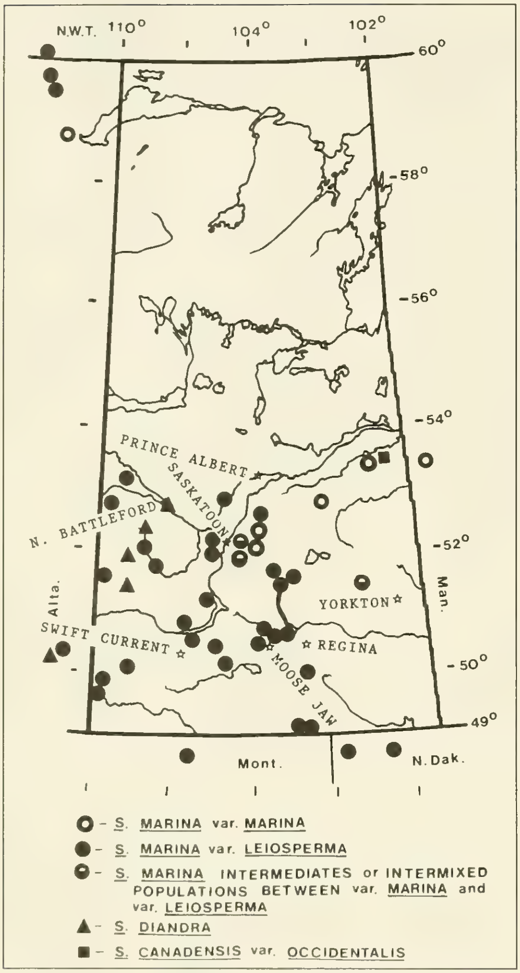
N.W.T.
110°
104°
102°
60°
-58°
-56°
-54°
-52°
-50°
49°
PRINCE ALBERT
SASKATOON
N. BATTLEFORD
YORKTON
REGINA
SWIFT CURRENT
MOOSE JAW
Alta.
Man.
Mont.
N. Dak.
○ - S. MARINA var. MARINA
● - S. MARINA var. LEIOSPERMA
◐ - S. MARINA INTERMEDIATES or INTERMIXED POPULATIONS BETWEEN var. MARINA and var. LEIOSPERMA
▲ - S. DIANDRA
■ - S. CANADENSIS var. OCCIDENTALIS

FIGURE 1. Recorded distribution of *Spergularia* taxa in Saskatchewan.

seems to hold reasonably well for the available Saskatchewan specimens. Such a tendency, at least, seems apparent, although floral bract length could hardly be used as a sole distinguishing character. The two varieties may be separated by use of the following taxonomic key:

Key to Varieties of *Spergularia marina* in Saskatchewan

1a. Seeds smooth-surfaced, lacking glandular-papillae; middle floral bracts mostly 4 mm long or more; inflorescence usually appearing more open, leafy, and not well differentiated from lower plant portions. . . . . var. *leiosperma* (Kindb.) Guerke

1b. Seeds ± densely glandular-papillose; middle floral bracts mostly shorter than 3.5(-5) mm long; inflorescence usually appearing more congested and better differentiated from lower plant portions. . . . . var. *marina*

Spergularia marina var. *marina* [synonyms: *S. salina* J. & C. Presl.; *S. sparsifolia* (Greene) A. Nels.], with glandular-papillose seeds, has been verified in Saskatchewan from near Dana (30 July 1937, *R. C. Russell*, DAO, SASK, SCS); Tisdale (29 July 1940, *A. J. Breitung #804*, DAO); vic. Pakwaw Lake Village, Shoal Lake Indian Reserve, (9 Sept. 1983, *R. R. Hooper #83-09-09-02*, SASK; 18 July 1984, *V. L. Harms, D. F. Hooper & L. Baker #32851*, SASK); and near Meacham (6 Aug. 1986, *J. Kranabetter #70*, SASK) (see Figure 1). Records of the typical variety *marina* appear lacking in Saskatchewan from west and south of the general Saskatoon area, but the author has personally seen papillose-seeded specimens from even farther west in northeastern Alberta (Mamawi Lake, 24 Aug. 1969, *D. & K. Dabbs 300*, SASK), and Rossbach (1940) also cited such plants from Wood Buffalo Park.

Spergularia marina var. *leiosperma* [synonym: *S. leiosperma* (Kindb.) Fern.], with smooth seeds, is our most common taxon. It has been recorded from the "Saskatchewan Plains" (near Fort Carlton) (19 August 1872, *J. Macoun 287*, GH); W of (the N end of) Long (i.e. Last Mountain) Lake (10 July 1879, *J. Macoun 2674*, CAN, & *284*, DAO); Cypress Hills (4 Aug. 1980, *J. Macoun s.n.*, DAO); 15 mi. w of Saskatoon (29 July 1906, *J. Macoun & W. Herriot 70906*, CAN, GH): Lake Manitou, W of Battleford (1 July 1935, *A. W. Anderson s.n.*, DAO) (2 July 1945, *H. Groh #2445*, DAO) (1 Aug. 1947, *C. Frankton #416*, DAO); Wakaw (11 Aug. 1937, *H. W. Mead & R. C. Russell s.n., DAO, SASK*); Kelsten (12 and 13 Aug. 1939, *W. P. Fraser s.n.;* SASK, SCS); Nokomis (23 Aug. 1940, *J. B. Campbell, s.n.*, SCS); Tramping Lake (22 July 1940, *J. B. Campbell, s.n.*, SCS); 3.5 mi. N of Hoosier (29 Aug. 1945, *L. Jenkins s.n.*, DAO); Little Manitou Lake, Watrous (15 Aug. 1946, *H. A. Senn #2943*, DAO); Sheho (20 July 1947, *C. Shaw #202*, SASK); Coteau Lake, near Dunblane (8 Aug. 1951, *B. Boivin & J. M. Gillett #8619*, DAO, SASK); Hawoods (1 July 1952, *J. H. Hudson #994*, DAO, SASK); 7 mi. W of Maple Creek (3 Aug. 1958, *I. J. Bassett & B. G. Cumming #3852*, DAO); Qu'Appelle Valley, 20 mi. NE of Moose Jaw (13 July 1960, *G. F. Ledingham & B. M. Rever #2872*, DAO, USAS); Matador (14 June 1960, *J. Looman #5501*, SCS); Jim Creek Lake, Big Muddy Valley (31 July 1966, *H. Morrison #68-373*, USAS): S of Big Muddy Lake (3 July 1968, *H. Morrison #68-220*, SASK, USAS); Qu'Appelle Valley, 7 mi. N of Stony Beach (21 July 1970, *G. F. Ledingham & G. J. Jones #5252*, SASK, USAS; 21 July 1970, *G. F. Ledingham & G. J. Jones #5252*, USAS); S of Morse (29 Aug. 1974, *J. Looman*

#20282, SCS); vic. Plenty (8 Aug. 1976, *J. H. Hudson #3219,* DAO, SASK, USAS); Patience Lake, 10 mi. E of Saskatoon, (July 1977, *N. A. Skoglund s.n.,* SASK); E of Stewart Valley (14 June 1977, *J. Looman #21812,* SCS); 14 mi S of Corinne (10 Sept. 1978, *G. F. Ledingham #5964,* DAO, USAS); Crane Lake area (21 June 1978, *L. Townley-Smith #78194,* SASK); Rice Lake (23 Sept. 1979, *J. H. Hudson #3867,* DAO, SASK, USAS); Qu'Appelle Valley, N of Rocky Lake (31 Aug. 1980, *R. St. Pierre #28,* SASK); NW of Caron (1 Sept. 1982, *G. F. Ledingham #7874,* USAS); Qu'Appelle Valley, 9 mi. N of Stony Beach (26 Sept. 1985, *G. F. Ledingham #9458,* CAN, USAS; 22 Sept. 1987, *G. F. Ledingham #10261,* USAS) (see Figure 1).

Spergularia marina collections that appeared intermediate or were mixed between varieties *marina* and *leiosperma* (i.e. with some seeds ± distinctly glandulose-papillose, others only very sparsely so, and some smooth) were found from E of Blucher (1 Aug. 1957, *J. D. Dodd & J. S. Maini #20,* DAO, SASK); 10 mi. E of Saskatoon (probably Patience Lake) (26 July 1950, *G. F. Ledingham #940,* DAO, USAS); Patience Lake, 10 mi. E of Saskatoon (25 July 1943, *O. C. Furniss #51197,* DAO, SASK); Sheho (20 July 1947, *C. Shaw #202,* DAO) (see Figure 1).

Reportedly, plants of both *S. marina* varieties may vary from having essentially glabrous, or sparsely, to densely glandular-pubescent sepals, pedicels, upper stems, middle and lower stems, and leaves. But all Saskatchewan specimens of *S. marina* var. *leiosperma* and most of var. *marina* were quite densely glandular-pubescent throughout. Only the Shoal Lake collections of var. *marina* revealed nearly glabrous to somewhat glandular-ciliate leaves, only sparsely glandular-pubescent middle to lower stems, and upper stems, pedicels, and sepals moderately glandular-pubescent. No seeds of Saskatchewan collections of *S. marina* var. *leiosperma* revealed any wings, while 4-6% of the seeds of var. *marina* plants from Shoal Lake and Meacham were weakly winged, although other collections were not. The key character, "stipules as long or longer than broad", often used to help distinguish *S. marina* from other species (e.g. Rossbach 1940; Fernald 1950; Scoggan 1978) appears inconsistent in Saskatchewan materials, but the stipules of *S. marina* are more connate and sheathing than those of *S. diandra.* Whenever petals were observable on Saskatchewan specimens of both varieties of this species, they mostly appeared ± pinkish to deeply roseate, rather than white. But corolla color would seem a rather uncertain character to accurately record from herbarium specimens.

2. *Spergularia diandra* (Guss.) Boiss. — Two-stamened Sand-spurrey. [Synonyms: *S. atheniensis* Heldr. & Sart.; *S. salsuginea* (Bunge) Fenzl.].

This native species of Eurasia is naturalized in western North America, occurring sparingly in the Snake, Columbia and Okanagan River valleys of Oregon and Washington, eastward and northwards to Idaho and Kamloops, British Columbia, and in eastern North America occurring locally in Massachussetts and Georgia, in addition to the few localities known from our region in the continental interior in southwestern Saskatchewan and southeastern Alberta. Reported habitats for the species are ± saline or alkaline, sandy or gravelly, drying depressions and slough bottoms, and saline lake-shore and mud-flats. In Saskatchewan, the plants appear rare, having been collected only from the vicinity of Scott (28 July 1932, *F. M. McIsaac,* DAO, SASK, SCS); Kindersley (10 August 1955, *E. H. Moss #10781,* DAO); 8 mi. S. of Kerrobert (16 July 1966, *J. F. Alex & J. P. Gebhardt #2644,* DAO); and Battleford (26 July 1971, *J. H. Hudson 2738,* SASK, USAS). In adjacent Alberta, it has been recorded at least from NW of Redcliff (NW of Medicine Hat) (11 August 1953, *E. H. Moss #10422,* ALTA, DAO). (See Figure 1).

Plants of this species tend to be somewhat smaller, more often prostrate, more slender-stemmed, and less branched below, with their mature capsules shorter and globose, in contrast to plants of *S. marina.* But the most characteristic features that distinguish *S. diandra* from *S. marina* and *S. canadensis* are those of the mature seeds, which are distinctly smaller, 0.5 mm long or less, pyriform rather than sub-reniform in shape, distinctly black with a silvery tinge, and ± distinctly rugulose (see Figure 2). While this species is potentially weedy, its rarity in Saskatchewan and Alberta, precludes its being categorized as such here.

3. *Spergularia canadensis* (Pers.) G. Don var. *occidentalis* R. P. Rossbach — Canada Sand-spurrey.

This taxon is a surprising one to be found in Saskatchewan, but it seems the only one to which we can refer a unique *Spergularia* population from the Nitenai River area. Previously, the North American native species, *S. canadensis,* has been known only from maritime coastal saline marshes. Typical var. *canadensis,* with glabrous sepals and herbage, is found along the Atlantic Coast from Labrador to New York, including the Gulf of St. Lawrence, on both east and west coastlines of James Bay, and along the Pacific Coast from southern Alaska to northern British Columbia.

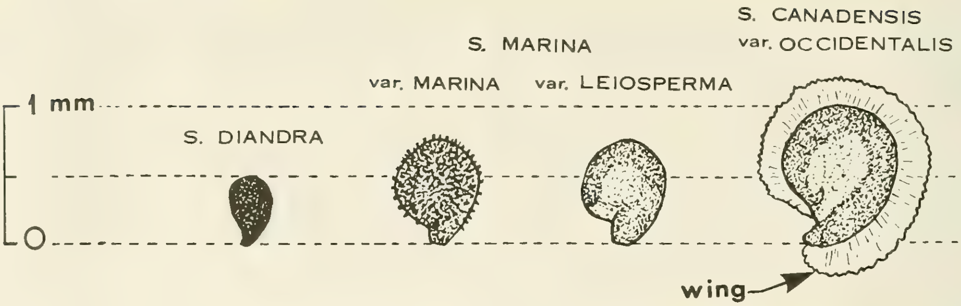

FIGURE 2. Comparison of seeds of *Spergularia* taxa in Saskatchewan.

Occurring farther south along the Pacific coast, from Vancouver Island to California, is *S. canadensis* var. *occidentalis*, with glandular-pubescent sepals, pedicels and upper stems, and glandular-ciliate leaves (see Figure 3).

We have assigned the following east-central Saskatchewan population from the Nitenai River to *S. canadensis* var. *occidentalis* because it appears identifiable only as this taxon. The plants of this population are localized near open pool edges at raised NaC1 springs, within the extensive Nitenai River saline marshes, in the Carrot River Valley, at northern base of Pasquia Hills, bordering the south shore of Nitenai River, ca. 80 km N of Hudson Bay Jct., S22-T53-R2 W2; 53°35′25″ N, 102° 13′W (17 July 1984, *V. L. Harms, D. F. Hooper, & L. Baker 32,767,* SASK; 1 Aug. 1987, *G. F. Ledingham et al. 10180,* USAS, SASK) (see Figures 1 and 3). The Nitenai River saline marshes appear quite well removed from human-disturbances, including no known introduced weeds, so this *Spergularia* population would certainly appear indigenous.

This single Nitenai River population is relatively well sampled, with about 35 individual plant specimens included in the two cited collections which were carefully studied and recorded. The plants of this population may be characterized in habit as ascending to erect, slender annuals, largely unbranched below and sparingly so above, with stems 4-11 ($\bar{X}$ = 7) cm long. The leaves are not fascicled, those below the inflorescence 9-25 ($\bar{X}$ = 15) mm long and 0.4-1.2 mm wide, with either obtuse or acute, thin-foliate, non-mucronate apices. Their stipules are mostly about 1.2-2 ($\bar{X}$ = 1.5) mm long and about as wide. The inflorescences are rather open and leafy, with middle floral bracts mostly over 3.5 mm long, similar to those of *S. marina* var. *leiosperma*. The pedicels and upper stems are quite densely glandular-pubescent, but the middle and lower stems only sparsely so. The glandular-hairs appear more slender (i.e. somewhat longer and with smaller capitate tips) than do those of *S. marina*. The sepals are ovate, obtuse, 2.5-3.8 mm long, and ± densely glandular-pubescent. The petals are pinkish, 1.8-2.3 mm long, about 2/3 the sepal length. The stamen number varies from 2-4. Mature capsules are 4-5.5 mm long, mostly about 1.5 mm longer than the calyx. The seeds are subreniform in shape, 1.0-1.2 mm long, medium to darker brown, all smooth-surfaced, lacking glandular-papillae, with 96% distinctly wing-margined, the wings about 0.3 mm wide, whitish-scarious, mostly quite intact, somewhat erose-margined (see Figure 2). The large, non-papillose, consistently winged seeds and the non-mucronate leaves, in particular, are diagnostic of *S. canadensis*, and the distinctly glandular-pubescent sepals, pedicels and stems would place the plants of this population into the var. *occidentalis* of this species.

Our east-central Saskatchewan population from the Nitenai River saline marsh represents a widely disjunct, outlying station from the previously known range of *Spergularia canadensis*, appearing to be the first inland record for either variety of the species. That the plants seem quite clearly to belong to the Pacific Coast var. *occidentalis* rather than to the more widely distributed var. *canadensis*, is even more unexpected. The occurrence here of the latter would have allowed invoking the hypothesis of a possible former dispersal route for maritime species now disjunctly occurring in Saskatchewan via the marshy shorelines of a former post-glacial Hudson Bay connection to an estuarian-like receding Lake Agassiz such as we had earlier postulated for some other sea-coast halophytes (Harms et al. 1986). The extensive Nitenai River saline marsh, comprising an area of about 225 ha, is a particularly unique site for marsh-halophytes since it is the same inland locality from which several other characteristically maritime coastal marsh halophytes were also recorded, — viz. *Plantago maritima* L. and *Carex mackenzei* Krecz. (Harms

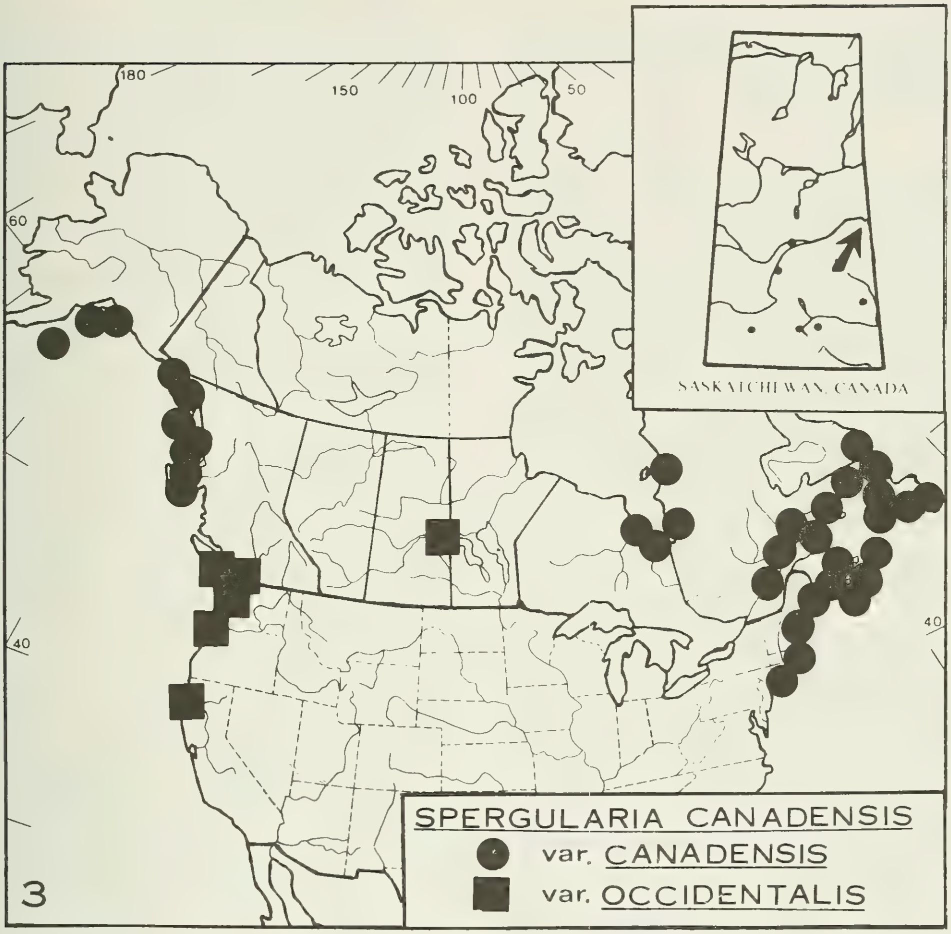

FIGURE 3. Distribution of *Spergularia canadensis.*

et al. 1986). As with *Plantago maritima,* the *Spergularia canadensis* plants were associated with the somewhat elevated areas of saline springs and associated pools surrounded by broad marsh flats. That the salinity of this and other Carrot River valley salt-marshes is mainly due to their sodium chloride content rather than to sodium sulfate characterizing most Saskatchewan saline lakes and marshes, may be a significant factor in the occurrence of these unique species here.

Because of the unexpectedness of our discovery of *Spergularia canadensis* var. *occidentalis* in east-central Saskatchewan, with its exceptional disjunction and "non-maritime" occurrence here, we delayed for some time the publication of this new provincial record until it could be carefully rechecked and compared with verified specimens from the Pacific Coast. This was done in conjunction with a broader study of variation in all Saskatchewan *Spergularia* species. It is with reasonable confidence that we now publish this new provincial record in the belief that our Nitenai River plants fit well into *S. canadensis* var. *occidentalis* and, in fact, this appears to be the only known taxon in North America into which they could be placed.

Other Possible Species

Besides the three, foregoing, sand-spurrey species that have been verified for Saskatchewan, possibly two other species, both more weedy introductions from Eurasia, could yet be encountered in the province, although their apparent absence even in adjacent provinces and states makes this unlikely.

Spergularia rubra (L.) J. & C. Presl. (Purple Sand-spurrey), an apparent introduction from Europe, has a known distribution along the

Atlantic, Gulf of Mexico, and Pacific coasts, in eastern North America extending sporadically inland, west to Michigan and Minnesota, and in western North America extending inland east to the Rocky Mountains of western Montana, and south to New Mexico. It has become a fairly common weed, especially in gardens, waste places and roadsides in western United States. It is characteristic of dry, sandy or gravelly, often sterile or disturbed, open soil, and, unlike most *Spergularia* species, is not limited to saline or alkaline substrates. Although most authors have considered this a naturalized species in North America, introduced from Europe, Fernald (1950) thought it probably indigenous at least along the Gulf of St. Lawrence, and Boivin (1966) seemingly concurred. Plants of *S. rubra* would be distinguishable from *S. marina* and *S. diandra* based on their (1) characteristic axillary fascicles (i.e. short leafy branches); (2) stipules conspicuous, lanceolate to narrowly triangular, 3.5-5(-6) mm long, distinctly longer than broad, long-tapering to acuminate apex, appearing multiple per node because of the axillary fascicles: (3) stamens more numerous, either 10 or with 1-4 of these aborted but still present; (4) seeds dark-brown, distinctly reticulate-sculptured and ± densely dark-papillose; and (5) sepals lanceolate rather than ovate.

Another species to look for in Saskatchewan is *Spergularia media* (L.) Griseb. (Intermediate Sand-spurrey) [synonyms: *S. marginata* (DC.) Kittel; *S. maritima* (All.) Chiov.]. This is a ± weedy species, native of Europe, long naturalized on the Pacific Coast, and also known in eastern North America from several coastal and inland localities in New York State (Rossbach 1940; Fernald 1950; Gleason and Cronquist 1963). More recently it appears to have spread rather rapidly in the east to inland localities in Illinois (Mohlenbrock and Evans 1974), Massachusetts, Quebec, and Ontario (Catling and McKay 1980), Ohio (Cusick 1983), and Michigan (Voss 1985). Plants of this species would best be looked for in various disturbed saline habitats, such as along roadside drainages of de-icing salt, potash mine and mill waste areas, city street snow dumps, etc. *Spergularia media* would be distinguishable from our three sand-spurrey species based on the plants (1) being more erect, robust and coarser, from a thick woody rootstock, often biennial or weakly perennial; (2) being more glabrous; (3) having characteristic axillary fascicles (i.e. short leafy branches); (4) having stipules appearing multiple per node (because of fascicles), to 6 mm long; (5) having sepals mostly 4-6 mm long; (6) having petals white; (7) having 9-10 stamens; (8) having mature capsules larger, 5.5-7 (-9) mm long, much exceeding the calyx; (9) having lower fruiting pedicels 1-2 cm long, and (10) having mature seeds dark-brown, not glandular-papillose, smooth or only delicately marked (0.6)0.8-1.1 mm long, and almost always distinctly winged.

Provincially Rare *Spergularia* Species

As a new provincial record of a taxon now known from a single locality in the province, *Spergularia canadensis* var. *occidentalis* should be added to the list of Saskatchewan's very rare plants. Although omitted from the Saskatchewan list by Maher et al. (1979), we had once thought that *Spergularia marina* should probably also be accorded provincially rare status. But the present compilation from the study of Saskatchewan specimens in various herbaria indicates that this species, or at least its variety *leiosperma*, is too frequent and widespread in the province to deserve a rare status as defined by the rare species program of the National Museum of Natural Sciences (Maher et al. 1979). The third Saskatchewan species of this genus, *S. diandra,* while indeed rare in the province, presumably represents a naturalized introduction here.

Acknowledgments

Thanks are extended to George F. Ledingham, University of Regina, whose keen laboratory observations first suggested and helped to confirm the presence of *Spergularia canadensis* as a new Saskatchewan record, but who subsequently declined co-authorship of this paper. Thanks are also due to Donald F. Hooper, of Somme, Saskatchewan, for discovering and appreciating the potential botanical significance of the Nitenai River salt marshes, and for his valuable collaboration in the field. The cooperation of the curators of the afore-cited herbaria for their loans of Saskatchewan *Spergularia* is gratefully acknowledged, as well as of WTU for the kind loan of comparative materials of *S. canadensis* varieties. Thanks are further due to Joan Ryan who competently typed the various versions of this paper.

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Breeding of the Scarlet Tanager, *Piranga olivacea,* in Western Manitoba

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Sightings of the Scarlet Tanager (*Piranga olivacea*) in the Riding Mountain National Park — Dauphin area, Manitoba, were recorded from 1972 through 1987. In the study area, territorial males were located by the author in 1976 and pairs were first seen in 1977. Nests were found and documented in 1982 and 1986. These records extend the known breeding range of the species into western Manitoba.

Key Words: Scarlet Tanager, *Piranga olivacea,* singing males, pairs, nests, Bur Oak, *Quercus macrocarpa,* Western Tanager, *Piranga ludoviciana*, photographs, Riding Mountain National Park, western Manitoba.

In Manitoba, the Scarlet Tanager (*Piranga olivacea*) was known in the southeastern part of the province, with breeding records at Whitemouth and Indian Bay (Godfrey 1986). In this paper, I document Scarlet Tanager reports and my own observations from Riding Mountain National Park and vicinity. These indicate that the species is now a regular, though local and uncommon, breeding bird in this part of western Manitoba.

Study Area

Riding Mountain National Park (RMNP) lies in the Manitoba escarpment in western Manitoba between 50°40′ and 51°N latitude and 99° 30′ and 101° W longitude. The plateau rises gradually from the south and southwest, reaching an altitude of 725 m and then dropping abruptly on the north and east edges to the former lake bottom of Lake Agassiz, now the aspen parkland, at about 200 m. Deep gorges and ravines cut through the escarpment walls.

Mixed aspen (*Populus tremuloides*) — spruce (*Picea glauca, P. mariana*) forest on the plateau merges with pure stands of aspen halfway down the escarpment slopes. Near the foot of the slopes, gravel ridges of former lake beaches — known locally as "The Bench" — support Bur Oaks (*Quercus macrocarpa*) which occur with aspens or in almost pure scrubby stands. Dense growths of Hazels (*Corylus* sp.) occur in the semi-open oak communities. Below "The Bench", aspens usually dominate, with eastern hardwoods such as American Elm (*Ulmus americana*), Manitoba Maple (*Acer negundo*) and Green Ash (*Fraxinus pennsylvanica*) at or near the base of the slope. Paper birch (*Betula papyrifera*) grows abundantly in the gorges and ravines. Where the gorges emerge from the Riding Mountain, these hardwoods with some aspens, Eastern Cottonwoods (*Populus deltoides*), Balsam Poplars (*Populus balsamifera*) and a few large oaks form gallery forests along the streams.

Observations were made fairly regularly during the breeding season in four areas between 1976 and 1987. All sites were immediately north of RMNP at the base of the escarpment, within 6.5 km east of Highway 10 which runs through and north of the park to Dauphin (Figure 1). These areas include:

Carmichael Forest (CF)

CF consists of fairly dense eastern hardwoods along Jackfish Creek which flows from southwest to northeast. Climax aspen forest occurs to the south toward Riding Mountain. North of the creek, scattered Bur Oaks and American Elms form the edge of the forest along a pasture. A large mature aspen grove extends east of the pasture to a swampy area, "The Beaver Pond." This pond is separated from the creek by gallery hardwoods.

My observations at CF began in 1976, but the land owners, Robert, David and Jack Carmichael, have been making casual observations of birds in this area since the 1920s. The moist closed canopy woods attracted a pair of Wood Thrushes (*Hylocichla mustelina*) which nested on the south side of the creek in 1976 (Walley 1977).

Durston Park (DP)

DP is a summer youth camp with several buildings and a large athletic field. Immediately south of this site is a deep gorge with a shallow impoundment of water behind a dam on Jackfish Creek. Aspens dominate the south slope of the gorge with hardwoods on the north slope where the gradient is not too steep. Bur Oaks and aspens grow between the gorge and the athletic field. I commenced observations at DP in 1976.

Inkster Forest (IF)

IF is a typical eastern hardwood climax forest with mature elms, maples and ashes. The forest

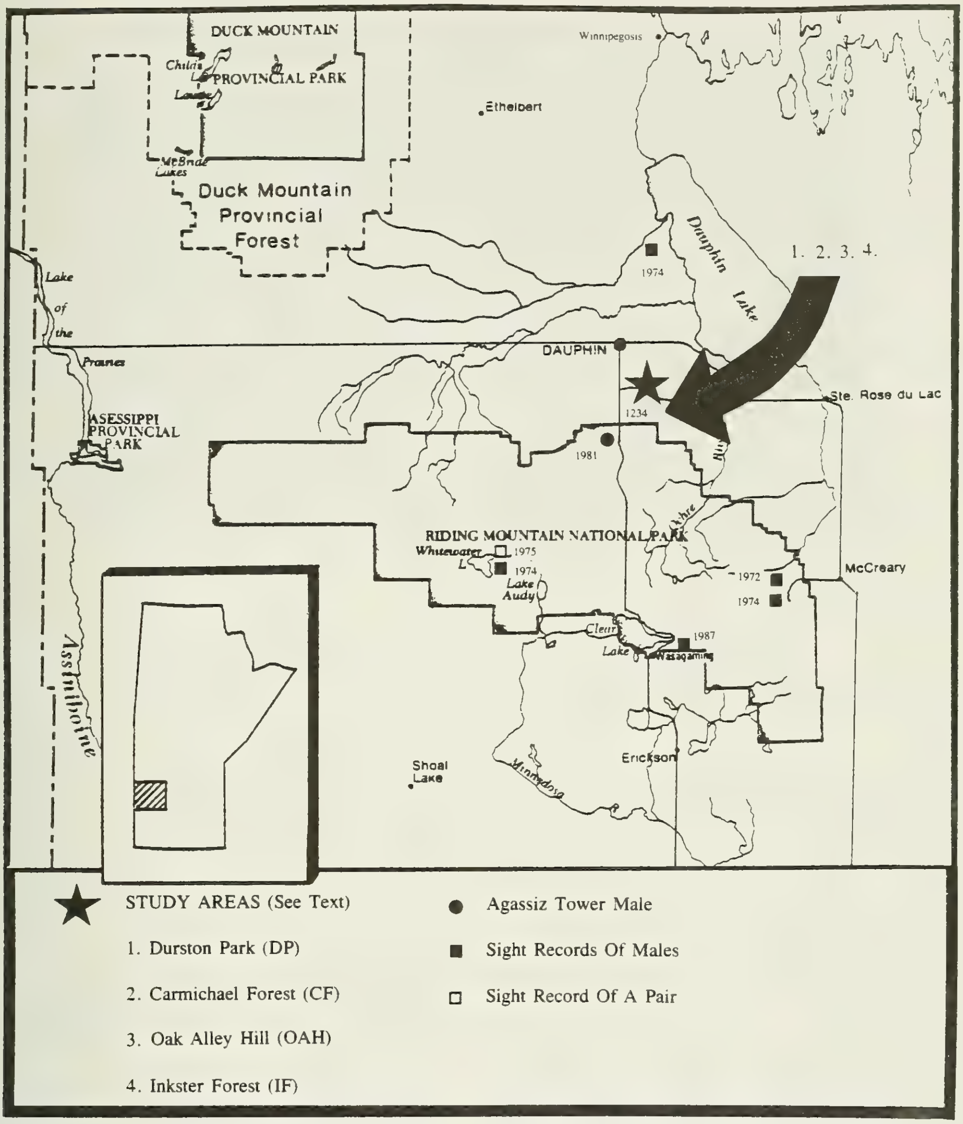

FIGURE 1. Locations of Scarlet Tanager, *Piranga olivacea*, study sites and incidental sightings in the Riding Mountain National Park area, 1972-1987.

floor supports dense growths of ferns, reflecting the moist nature of these woods. Most observations at IF have been made from a narrow north-south dirt road which winds through the forest parallel to a spring water runway. The edge effect created by this creek bed and the road attracts the tanagers. Observations began in 1983.

Oak Alley Hill (OAH)

OAH is a 32-ha area on the gravels of former beach ridges. Today it supports Bur Oaks from 8 to 22 m in height, with dense growths of Hazel in the semi-open areas. Aspens grow on richer soil adjacent to the gravel area. Observations here began in 1985.

Early Records in Western Manitoba

The first Scarlet Tanager reported in the area was a male, on 2 July 1972, 3.3 km west of the RMNP entrance to the Agassiz ski area straight west of McCreary, Manitoba. The bird was sighted near the old Agassiz beaches known locally as "The Oak Ridge" (H. W. R. Copland, Manitoba Museum of Man and Nature, personal communication) R. J. Walker, then of RMNP, located a male in this area, 12 June 1974.

Adrian G. Baker (personal communication) reported a male along the Valley River, 29 May 1974, 3 km west of Lake Dauphin and 35 km north of Riding Mountain. I located and identified a male, verified by R. J. Walker, in mixed forest at Whitewater Lake in the south part of RMNP, 1 June 1974. A male and female, probably a mated pair, were seen in the same area, 31 May 1975, by the author, L. J. Stephen and D. Stephen.

Observations and Discussion

At CF, the Carmichael brothers first identified Scarlet Tanagers in 1973 or 1974. They had not seen any in approximately 50 years of prior observations in the area. A pair built a nest there in 1975, but the attempt failed (B. Carmichael, personal communications).

Table I summarizes sightings of singing males, pairs and nestings made mainly by the author from 1976 through 1987. Most "Discrete Singing Males" were seen several times in each month for which sightings were noted.

The first pair of Scarlet Tanagers identified in the study area was at CF, 28 May 1977, at 09:45. The male, followed at times by the female, responded positively to the song of a territorial male played from a cassette tape. The playback and reactions continued off and on for the 45 minutes that I remained in the area. That evening, the male, followed by the female, appeared when the tape was played, this time not manifesting undue alarm. The male was seen in the area 29 May, 4, 7, 11, 12 and 16 June. D. Carmichael reported a probable second male in the area on 7 June. A male and female foraged in the tree tops, 4 July. The male flew off, returning shortly.

TABLE 1. Territorialism and nesting evidence of Scarlet Tanagers, *Piranga olivacea*, near the North Boundary of Riding Mountain National Park, 1976-1987.

	Number of Discrete Singing Males Located			Nesting Records and other Breeding Evidence
	May	June	July	
1976		1 CF*	1 CF	
		1 DP*		
1977	1 CF	1 CF	1 CF	CF: A pair on 28 May
		1 DP		CF: 2 males and 1 female together, 4 July
1978	1 CF	1 CF		CF: 2 males on 11 June
				CF: A pair on 20 June
1979			1 CF	
1980			1 CF	
1981			1 AT*	
1982		1 CF		
		1 DP		DP: A pair on 13 June
				DP: A nest with incubating female, 13 June
				DP: Adults feeding 5 young, 25, 27, 29 and 30 June
1983		1 CF		CF: A pair on 11 June
		1 IF*		
1984		1 DP		
1985	2 CF	2 CF	1 CF	CF: 2 males fighting on 25 May
				CF: 2 males, one carrying a worm, female nearby, 2 June
				CF: 2 females fighting on the ground, male perched nearby, early June (J. Carmichael, personal communication)
		1 OAH*	1 OAH	
			1 DP	
			2 IF	
1986	1 IF	1 IF	1 OAH	IF: A pair on 28 May
		1 CF	1 CF	CF: A pair displaying extreme alarm, 21 June
				CF: A nest with the female sitting tight, 22 June
1987	1 CF	1 CF	1 CF	
		1 IF		
		3 OAH	1 OAH	OAH: A pair, 16, 17, 20 and 26 June
				OAH: 2 males seen twice, 16 June
				OAH: 2 males seen twice on 8 July and on 10 July
				OAH: 2 females seen, 26 June

*AT = Agassiz Tower (Riding Mountain National Park); CF = Carmichael Forest; DP = Durston Park; IF = Inkster Forest; OAH = Oak Alley Hill.

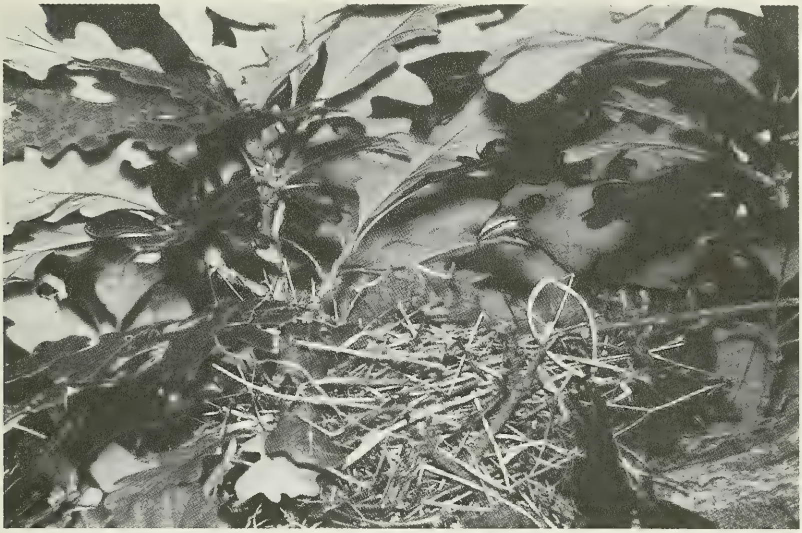

FIGURE 2. Male Scarlet Tanager at nest in Bur Oak at Durston Park, Manitoba, 29 June 1982.

Subsequently two males were seen within 3 or 4 meters of one another.

Agassiz Tower is a public viewpoint about 3 km south of the north entrance of RMNP and about halfway up the face of the escarpment. A "red bird" was reported to me there in late June 1981, and a singing male Scarlet Tanager was identified on 2 July. From the tower and the edge of the gorge, 5, 9, and 10 July, this male's territory was delineated by observing it and hearing it sing from various trees on and above the walls of the gorge. The habitat was mainly dense aspen forest with a few White Spruces above the gorge and a few scattered White Spruces on the gorge walls. Several photographs were obtained of this bird as it was drawn close to the tower by the playback of the species' territorial song. No female was seen there.

A Scarlet Tanager nest was located at DP by P. Clark and J. Clyde, 13 June 1982, when they saw the female dive straight down into the shrubs below as they walked by the nest tree. This behavior was repeated when I walked past a few minutes later. The nest was placed among a clump of leaves well out on the branch of a Bur Oak, 5.5 m above the ground. The tree was near the edge of dense aspen forest. The female was apparently still incubating on 21 June, but the adults were feeding young on 25 June. Photography equipment including a long stepladder was brought to the site on 29 June (Figure 2). Between 05:00 and 07:45, the five young were fed seven times — all by the male. The female, displaying alarm due to the presence of the camera, did not bring food to the young but remained in the vicinity of the nest. An unidentified yellowish, tanager-sized bird was seen near the nest.

In the early morning of 30 June, the adults brought food to the nestlings until the camera was set up, then only the male fed. People began to pass nearby and at this point it was noted that the young had not been fed for about 45 minutes. Two young women, one with her hands cupped closed to her body, approached my assistant and me. She was carrying the male, which had collided with a window of the main building and had fallen to the ground where they found it! The bird recovered shortly, flew and perched for 7 minutes. It then flew and perched higher up for 20 minutes. During this time it was visited by a pale yellowish, tanager-like bird which came to within 0.3 m of the dazed tanager. Observed at 35 m with a 20x telescope on a tripod, the strange bird had two prominent whitish wing bars, light yellow breast, face, nape and head. The back was dark with a yellowish rump. The upper parts and head of this bird, which was believed to be the one seen briefly on 29 June, contrasted with the uniform olive-green of the female Scarlet Tanager. A photograph of a Western Tanager (*Piranga ludoviciana*) (Farrand 1983) suggests that this was a female of that species or a male which was lacking the red on the head. Although Western Tanagers are not known to breed this far east (Godfrey 1986), a few sight records of singing males exist, all in May, identified by Walley (1975) in RMNP; E. Dandridge at Birtle in 1982 (personal communication) and W. L. Clark in Dauphin in 1983 (personal communication). This bird, presumably unable to find a mate, associated itself with this pair of Scarlet Tanagers.

The male Scarlet Tanager dropped downward from its perch, but the young continued to be neglected. When I climbed the ladder to remove the camera, the tanager pair and the possible Western Tanager appeared suddenly, scolding and thrashing about from branch to branch in wild panic. The two females approached to within 4 m of me at the top of the ladder and the male came within 8 m. Normal feeding of the young resumed when the camera and ladder were removed. On 2 July, the young were accidently flushed from the nest and fluttered down into the shrubs below. This is the first documented nest of this species in Canada west of Winnipeg (Figure 2).

During a trip to CF 25 May 1985, F. Fisher and I witnessed a spectacular aerial conflict between two males in rich spring plumage. Five mid-air clashes and skirmishes each lasting several seconds were observed among the tree-tops along Jackfish Creek. The males were watched for over five minutes.

A pair of Scarlet Tanagers displayed extreme alarm at CF, 21 June 1986. The following day as I approached the area, the male flew 100 m south and sang. The nest was quickly found 3m up on the lowest limb of a Bur Oak at the edge of a 0.4 ha grassy opening in the forest. The female sat tightly on the flimsy structure watching intently, and was doubtless incubating. On 29 June, the female continued to sit tight while the male gave "Chip-brrr" alarm notes in the nearby forest. The male was again giving alarm notes nearby on 3 July when the nest was empty. The male was singing there on 17 July.

At OAH in 1987, Scarlet Tanagers were observed regularly from 6 June until my last visit on 10 July. Pairs were observed on different dates but no nest was found. More than one pair probably occurred. One male chased another male while a third sang 16 June. A pair and a second female were seen 26 June. One male chased another male 10 July.

Additional Area Report

A singing male was found near Lake Katherine on the south boundary of RMNP by F. Fisher and I on 27 June 1987. The bird, an orangeish individual with a buffy-white patch on the right flank above the leg, sang in mature aspen forest.

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Sélection Granulométrique pour la construction du nid chez l'Hirondelle à front Blanc, *Hirundo pyrrhonota*

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Nous avons émis l'hypothèse que l'Hirondelle à front blanc sélectionne ses matériaux selon la texture qui confère adhésion aux particules choisies et solidité au nid et qu'elle choisit ses matériaux de façon à réduire le temps et à rentabiliser l'énergie consacrés à chaque transport de matériel. En effet, en aménageant des sites de matériaux aux propriétés différentes, un site plus rapproché est préféré si le même matériau est disponible plus près de la colonie et le matériau optimal présente des propriétés granulométriques plus adhésives pour façonner le nid: fortes proportions d'argile (21,3%) et de silt (45,2%) et une proportion moyenne de matière organique (5%). Un site au matériau dont les propriétés sont les moins adhésives, i.e. très sableux ou à faible teneur en matière organique, n'est pas sélectionné. Ces résultats sont discutés en fonction des propriétés physico-chimiques des particules élémentaires qui entrent dans la composition du nid.

We tested the hypothesis that Cliff Swallows select nest material for the texture that would allow for greater tensile strength between the particules and for greater solidity of the nest, and that they choose this material to reduce traveling time to the nest, thus minimizing energy expenditure. Indeed, by offering sites with different materials, sites closer to the colony were prefered, as well as sites with materials containing more adhesive particules for nest building. These higher proportions of clay (21.3%) and silt (45.2%) and an average amount of organic matter (5%). Sites with less adhesive material, containing too much sand or too little organic matter, were avoided. These results are discussed in light of the physicochemical properties of the basic particles that were used in nest building.

Key Words: Cliff Swallow, *Hirundo pyrrhonota*, nest material, selection, energy expenditure.

La variation de l'architecture et des matériaux utilisés pour construire le nid chez les oiseaux est étonnante (Nickell 1958). Le nid de l'Hirondelle à font blanc (*Hirundo pyrrhonota*) est particulièrement intéressant par sa structure. Prenant la forme d'une gourde, le nid est construit essentiellement à l'aide de boulettes de boue. Leur nombre, pour un nid moyen, oscille généralement autour de 1200 boulettes. À cause de la disponibilité de matériel, les colonies s'installent près d'une source de boue et de nourriture (Emlen 1952, 1954; Mayhew 1958).

Le nid est construit le plus souvent sous les corniches de bâtiments ou sous les ponts, mais préférablement contre un angle à deux faces, soit à la rencontre du mur et de la toiture ou de deux poutres, ou dans un coin contre trois faces, par exemple à l'intersection du mur, de la toiture et d'une poutre. Un vieux nid, en bon état, est souvent réutilisé.

La durée de construction du nid, qui peut s'étendre de 5 à 21 jours, est très variable et dépend des conditions environnementales: précipitations, vent, disponibilité des matériaux utilisés, et nourriture etc.

En raison de la qualité texturale des matériaux, on retrouve une certaine constance dans la composition granulométrique des nids. À ce sujet Kilgore et Knusen (1977) notent, pour un échantillon de cinq nids d'Hirondelles à front blanc, la composition suivante: 58,6-65,0 pour cent de sable, 23,8-27,4 pour cent de silt, 10,5-15,4 pour cent d'argile et 0,9-10,8 pour cent de matière organique. Les propriétés que possèdent les matériaux permettent au nid d'être suspendu sans grand danger de s'écouler, ce qui assure le déroulement normal de la reproduction.

La construction du nid exige une importante dépense d'énergie (Hails 1979; Tucker 1971, 1973). Ceci nous amène à penser que l'Hirondelle à front blanc choisit les matériaux d'une manière très sélective et qu'elle est sûrement confrontée à un choix de plusieurs matériaux. Ce choix de matériaux de qualité adéquate est déterminant compte tenu de la répercussion que pourraient avoir des matériaux de piètre qualité sur le succès de reproduction (Emlen 1954; Foster 1968). Dans le cas où elle dispose naturellement d'une grande variété de matériaux, l'Hirondelle à front blanc devra faire un compromis entre la qualité de la texture du matériel et la distance entre la source et le lieu du nid parce qu'il est plus coûteux de devoir aller cueillir des matériaux à plus grande distance du nid.

Intuitivement, on peut supposer que plusieurs facteurs influencent un tel choix. Ils n'ont cependant jamais été mesurés. Par exemple, un matériel de très bonne qualité pourrait être ignoré si un matériel de qualité inférieure mais conservant certaines normes de cohésion et d'adhésion, se trouve à proximité. Le sol peut être caractérisé par sa texture, ou composition granulométrique, qui est définie par la proportion des éléments du sol classés par catégories, sable, silt et argile, après destruction des agrégats. Les propriétés texturales des matériaux employés, grâce aux capacités de liaison des argiles, permettent l'adhésion au substrat et la cohésion entre les particules, ce qui assure ainsi une certaine solidité au nid et facilite l'utilisation de ces matériaux (Kilgore et Knusen 1977; Bonneau et Souchier 1979).

Précisons que ce sont les propriétés colloïdales de l'argile et la floculation de ces colloïdes qui assurent la stabilité de la structure que prennent les particules élémentaires entre elles et qui entrent dans la composition du nid de cette espèce. Les hydroxydes de fer et d'aluminium, colloïdes électropositifs, favorisent également la cohésion des particules du même que l'élaboration des agrégats de particules sans liens entre eux. Les matières organiques humifiées jouent aussi un rôle de ciment entre les particules minérales, soit directement par les liaisons entre les charges électriques de l'argile soit par l'intermédiaire des cations de fer, notamment d'aluminium (Bonneau et Souchier 1979). Ces matières devraient donc être importantes dans le choix que l'hirondelle fait d'un site de cueillette de matériaux de construction.

Dans ce contexte, les coûts énergétiques reliés au transport des matériaux et leur qualité découlant de leurs propriétés physiques, chimiques et biologiques, peuvent être déterminants pour la sélection de l'emplacement du matériel approprié.

Cependant, s'il y a une grande disponibilité de différents matériaux à courte distance, les hirondelles sont-elles en mesure d'effectuer un choix et de l'optimiser? Existe-t-il des normes intrinsèques à l'oiseau?

Afin de mieux comprendre comment l'Hirondelle à front blanc optimise le choix des matériaux pour la construction de son nid, nous poserons l'hypothèse suivante que l'Hirondelle à front blanc sélectionne ses matériaux selon la texture qui confère adhésion aux particules choisies et solidité au nid. L'Hirondelle à front blanc choisit ses matériaux de façon à réduire le temps et l'énergie consacrés à chaque transport de matériel.

Matériel et méthode

L'étude s'est déroulée à Sainte-Véronique, dans les Laurentides (46° 30′N, 75° 00′O). Le site de nidification utilisé pour l'expérience était un hangard en bois à proximité du village, à environ 500 m au sud du lac Tibériade et en contact avec les espaces libres du parc municipal, aménagé en gazon sur environ 2 km, près de la rivière Le Jourdain. La prise des données s'est effectuée du 17 mai au 6 juin 1987 dans une colonie d'Hirondelles à front blanc, composée de 30 couples. La plupart des observations ont été réalisées à l'oeil nu ou à l'aide de jumelles 7 × 35, à distance suffisante pour ne pas troubler le comportement des oiseaux.

Dans un premier temps, nous avons tenté de déterminer le nombre de sites naturels utilisés par les oiseaux de la colonie. Une seul a été trouvé (site #1). Il était situé à 100 m de la colonie, le long d'un sentier traversant une zone gazonnée où le sol avait été retourné et compacté par des véhicules motorisés à deux roues. Nous avons aussi localisé, autour de l'aire de nidification, des sites naturels qui nous semblaient pouvoir être utilisés par les hirondelles comme source de matériaux. Trois de ces sites (#5, 6 et 7) ont été retenus afin d'analyser la granulométrie de la surface du sol. Cette analyse «consiste à mesurer les proportions des divers diamètres des particules primaires du sol, soit par leur capacité à passer à travers des tamis de différents calibres, soit par leur vitesse de sédimentation dans l'eau» (Lambert et al. 1985). Ces sites étaient situés à l'est et au sud-est entre une zone gazonnée et la rive de la rivière le Jourdain ou du lac Tibériade, dans un rayon de 50 m à 250 m autour de la colonie d'hirondelles. À chaque site, nous avons pris un échantillon de boue homogène (30 g pour les matériaux fins et 100 g pour les sables; quantités requises pour l'application des techniques d'analyse granulométrique; et 0,2 à 2 g pour le dosage du carbone). Les prélèvements proviennent des cinq cm supérieurs de la couche du sol. Le sol d'une surface de 1 m^2 était prélevée en ramenant progressivement le sol des quatre points cardinaux vers le centre de cette surface pour homogénéiser le tout. Cette méthode suit celle proposée par Lambert et al. (1985).

Dans un deuxième temps et pour mettre à l'épreuve notre hypothèse, nous avons choisi un site sablonneux (95% de sable) pour y déposer 4 échantillons de boue d'environ 1 m^2 chacun, de granulométrie différente, provenant de sites naturels différents (situés à plusieurs kilomètres de la colonie). Chacun de ces échantillons deviendra un site artificiel (tableau 1). Le site #1 contient le même matériel que celui du site naturel déjà utilisé par les oiseaux à 100 m; le site #2 possède une texture silto-sableuse avec beaucoup d'argile; le site #3 ressemble au site #1 mais détient une forte proportion de matériel organique; le site #4 quant à lui représente le sol des champs environnants et sa texture est sablonneuse. Le fait d'employer un matériel très sablonneux sous-jacent aux sites expérimentaux est important pour éviter que l'oiseau ne choisisse ce matériau servant de support, et que ce dernier ne modifie la réponse de l'oiseau aux choix offerts (Kilgore et Knusen 1977). Ces sites offerts aux oiseaux de la colonie

TABLEAU 1. Granulométrie des sédiments des sites échantillonnés.

	Échantillons						
	Sites artificiels				Autres sites naturels potentiels		
	1[1]	2	3	4	5	6	7
Sédiments (%)[2]							
Sable (> 0,062mm)#	69,1	33,5	66,0	81,9	60,0	95,2	90,0
Silt (0,002-0,062mm)	24,0	45,2	25,4	18,1	30,7	4,8	10,0
Argile (< 0,002mm)	6,9	21,3	8,6	-	9,3	-	0,0
Détail des sables (%)[2]							
Très grossiers (1,25-2mm)	5,4	5,0	11,1	5,3	1,2	8,5	8,8
Grossiers (0,5-1,25mm)	12,4	9,3	18,5	13,9	5,9	30,9	24,8
Moyens (0,25-0,5mm)	29,5	11,3	18,8	27,6	22,8	32,3	32,6
Fins (0,125-0,025mm)	15,6	5,6	11,6	24,8	21,1	17,7	16,6
Trés fins (0,062-0,125mm)	6,2	2,3	6,0	10,3	9,0	5,8	7,2

[1] Mêmes matériaux que le site naturel déjà utilisé.

[2] La classification granulométrique est celle de Wentworth (*fide* Lambert et al. 1985).

pour leur quête de matériaux sont installés à 40 m à l'est de la colonie. Ainsi, les nouveaux sites conservent la même orientation cardinale que celle du site naturel par rapport à la colonie et la distance du site aux nids devient mesurable. Ainsi, en offrant aux hirondelles de nouveaux sites, à distance réduite de moitié (100 m pour le site naturel, 40 m pour les sites artificiels) et en limitant les variables du milieu, nous pourrons mieux comparer et comprendre les choix effectués par les oiseaux. Pendant la période de choix préliminaire, l'accès *ad libitum* aux sites naturels est maintenu, car il faudra apprécier et respecter le choix des hirondelles en fonction de la distance et de la qualité de la texture de la boue.

La préférence du matériel est évaluée par la fréquence relative (en %) de la présence des hirondelles à un site en particulier. L'importance respective de chaque site et matériau a pu être déterminée en retirant successivement, à intervalle d'une heure, l'accès au matériel préféré des oiseaux. Cette manoeuvre fut répétée durant deux jours, soit les 23 et 29 mai. De cette façon, nous avons pu évaluer l'ordre de préférence des hirondelles pour chaque site et matériau.

Nous avons aussi analysé la granulométrie (Lambert et al. 1985) et dosé le carbone organique (Sheldrick 1984) des échantillons de matériaux recueillis. Ces échantillons comprennent (1) les quatre carrés de boue (site #1 rapporté à 40 m et sites #2 à 4) de granulométrie différente offerts aux oiseaux; (2) le site naturel normalement employé par les hirondelles (site #1 naturel à 100 m); et (3) les sites potentiellement utilisables par les Hirondelles à front blanc (sites #5, 6 et 7). Ces derniers furent jugés possibles en raison de la structure adhésive et ferme que leur matériau présentait au toucher, selon des critères minimum d'adhérence des boulettes les unes aux autres et leur disponibilité pour les oiseaux.

L'analyse granulométrique consiste à mesurer les proportions des divers diamètres des particules primaires du sédiment, soit par leur capacité à passer au travers d'une série de tamis de différents calibres (dimensions des tamis AFNOR utilisés: #32/1,25 mm, #30/0,800 mm, #28/0,500 mm, #27/0,400 mm, #25/0,250 mm, #24/0,200 mm, #22/0,125 mm, #20/0,080 mm, #18/0,050 mm), soit par la méthode densimétrique de Mériaux, à savoir la vitesse de sédimentation des particules dans l'eau. Ces proportions sont exprimées par le poids relatif des particules à l'intérieur de certaines classes déterminées (Lambert et al. 1985).

Les limites des diverses classes granulométriques varient selon le système de classification. Nous avons utilisé ici celui de Wenworth modifié (*tiré de* Lambert et al. 1985), qui est le plus utilisé et qui classe les argiles selon les particules plus petites que 0,002 mm, les sables selon les particules plus grandes que 0,062 mm, et les silts selon les particules de taille intermédiaire. Il est entendu que les particules minérales sont complètement dissociées les unes des autres par des processus physiques et chimiques. Les échantillons séchés et broyés mécaniquement au moyen d'un mortier, ce qui n'altère pas la nature des particules, sont ensuite passés au tamis pour déterminer les proportions des différents sables.

Pour les fractions plus fines (silts et argiles), on les analyse par densimétrie. Ainsi, après destruction de la matière organique, on mesure la vitesse de chute des particules dans une allonge (cylindre de 1000 cc d'eau distillée). À cette fin, on utilise le densimètre de Mériaux pour mesurer la densité des particules en suspension des différents échantillons en fonction du temps et on les compare à un témoin (liquide de référence contenant 9% de pyrophosphate de sodium) (Lambert et al. 1985). Le pourcentage de chaque composante (argile et silt) est évalué à l'aide des lectures prises avec le densimètre sur les échantillons et sur le liquide de référence témoin à intervalles de temps déterminé.

Ainsi, les allonges échantillons et les allonges témoins reposent ensemble pendant huit heures pour que leur contenu soit à la même température. Après agitation des allonges, on prend des mesures au densimètre à la quatrième, huitième et 15e minutes, et à 8 heures et à 24 heures pour déterminer la vitesse de sédimentation des particules. On peut par la suite évaluer la dimension des particules en se servant d'un abaque sur lequel on a reporté la lecture de l'échelle de densité du liquide dans l'allonge en fonction du temps; il ne reste plus qu'à lire les dimensions des particules sur l'abaque. On peut ensuite estimer les proportions (en %) des particules correspondant à un même diamètre pour chaque lecture. Des corrections pour la température doivent par la suite être effectuées et pour cela on se réfère aux tables de correction de densimétrie selon la température. En cumulant les pourcentages sur l'échelle Wentworth, on obtient la proportion de chaque composante (argile, silt, etc.) (Lambert et al. 1985).

Le dosage du carbone organique a été effectué par voie humide et par méthode titrimétrique. Celle-ci consiste à faire agir un corps oxydant en excès (le bichromate de potassium) en milieu d'acide sulfurique concentré sur les sédiments. L'oxygène libéré oxyde le carbone organique dégageant ainsi du CO_2. L'oxydant en excès est ensuite dosé en utilisant un réducteur (sel de Mohr). Donc, en connaissant la quantité d'oxydant n'ayant pas réagi, on peut connaître par calcul de proportion, le pourcentage de carbone organique. La proportion de matière organique de l'échantillon peut ensuite être déterminée en multipliant la teneur en carbone par une constante (1,727) qui exprime le rapport proportionnel entre les deux (Sheldrick, 1984; Lambert et al. 1985).

Ces analyses nous permettent d'évaluer la texture des échantillons selon leur proportion d'argile (particules minérales plus petites que 0,002 mm), de silt (particules entre 0,002 mm et 0,062 mm) et de sable (particules plus grosses que 0,062 mm), selon la grosseur des sables (très grossiers (1,250-2,0), grossiers (0,500-1,250), moyens (0,250-0,500), fins (0,125-0,250), très fins (0,063-0,125)) et selon la proportion (en %) de matière organique des échantillons (tableau 1 et 2).

Les variances dans la préférence des matériaux, selon leur granulométrie, sont traités à l'aide d'une analyse de variance à un facteur de classsification.

TABLEAU 2. Proportion de matière organique dans les matériaux de construction des nids (échantillons de boue).

	Échantillons						
	Sites artificiels				Autres sites potentiels naturels		
Composantes organiques %	1	2	3	4	5	6	7
Carbone organique	5,0	2,9	14,5	1,4	11,1	0,7	0,4
Matière organique	8,7	5,1	25,1	2,4	19,2	1,2	0,7

Résultats

Les hirondelles n'ont utilisé, au cours de l'étude, qu'un seul site naturel situé à environ 100 m de la colonie, en plus des quatres sites artificiels offerts. Les différents sites naturels possibles répertoriés, représentés par les échantillons #5, 6 et 7 (tableau 1 et 2), n'ont pas été utilisés.

La composition granulométrique et organique de chaque site est résumée aux tableaux 1 et 2. On note en particulier au premier tableau que le site #2 contient le plus de silt et d'argile et le moins de sable, ce qui devrait en faire un matériau très adhésif, par rapport aux autres. Au contraire, les sites #6 et 7 contiennent le plus de sable, et ceci en fait, avec le site #4, les sites aux matériaux dont les propriétés sont les moins adhésives. Les sites #1, 3 et 5 se ressemblent par leur composition en silt et en argile, mais le site #3 se distingue des deux autres par une plus forte proportion de sables plus grossiers (tableau 1). De plus, le tableau 2 montre que les sites #3 et 5 contiennent le plus de composantes organiques.

Le tableau 3 exprime en fréquence relative les préférences des hirondelles pour les matériaux offerts aux sites artificiels. Ces résultats montrent que les oiseaux choisissent tout d'abord le matériel du site naturel utilisé auparavant (site #1), s'il est rapproché des sites de nidification (à 40 m). Toutefois, après environ 30 minutes d'ajustement comportemental, comme pour comparer la qualité des sites en visitant successivement les sites avant de saisir définitivement leur boulette, les oiseaux s'attardent finalement au matériel contenant la plus grande quantité d'argile (21,3%) et de silt (45,2%) et une proportion moyenne de matière organique (Kilgore et Knusen 1977). Soulignons que le site naturel contenait des proportions d'argile relativement faibles (6,9%) et des proportions moyennes de silt (24,0%) et de matière organique (8,7%), ce qui correspond aux analyses de Kilgore et Knusen (1977) dans des nids de l'Hirondelle à front blanc.

On note que lorsqu'on offre tous les types de matériaux (à 40 m), les hirondelles n'utilisent plus

TABLEAU 3. Préférence des matériaux selon leur granulométrie.

Préférence (%)	Sites de matériaux				
	1 (40 m)	2	3	4	1 (100 m)
Instantanée (n = 200)	98	2	0	0	0
Après 30 min. (n = 1814)	11	89	0	0	0
Après retrait du site préféré[1] (n = 400 pour chacun)[2]	100	-	0	0	0
	-	99	1	0	0
	-	-	39	0,5	60,5
	-	-	-	0	100

[1] La préférence du matériel utilisé, évaluée par la fréquence relative (en %) des oiseaux au site, fut effectuée le 23 mai et un réplicata le 29 mai.

[2] L'intervalle de temps pour les échantillonnages entre les retraits d'accès aux matériaux (-) est de une heure.

le site naturel situé à 100 m (tableau 3), si un matériel de qualité structurale équivalente ou supérieure en termes de cohésion, d'adhérence et de facilité d'utilisation, représenté par le site #2 dont le pourcentage est plus élevé en argile, est disponible à plus faible distance de la colonie (à 40 m) ($P < 0,001$).

Le site #3 est moins populaire mais préféré au #4 ($P < 0,001$). Si les sites #3 et 4 (à 40 m) sont les seuls disponibles, les hirondelles choisissent, dans 60 pour cent des cas, d'aller chercher leur matériel au site naturel situé à 100 m ($P < 0,001$). Le site #4 n'a été en aucun temps sélectionné. Notons aussi que le site #3 ne diffère du site #1 que par sa proportion élevée en matière organique ($P < 0,001$). Toutefois le site #1 est nettement préféré au site #3 ($P < 0,001$).

Le site #5 est relativement semblable au site #3 et possède une forte proportion de matière organique. Cependant, la coloration rougeâtre de ce matériel indique la présence de fortes concentrations de fer. Les sites potentiels #6 et 7 sont très sableux (> 95% de sable) et ont une faible proportion de matière organique (0,7 et 1,2%). Les propriétés d'adhésion et de cohésion entre les particules de ces derniers matériaux (considérés comme des sables) sont, à toute fin pratique, absentes lorsqu'ils sèchent (Bonneau et Souchier 1979). Ces sites n'ont pas été utilisés par les oiseaux.

Discussion

À son retour printanier à la colonie, l'Hirondelle à front blanc est confrontée à un choix varié de sites de matériaux pour construire son nid. Souvent, en milieu naturel, les hirondelles ne possèdent pas un vaste choix de matériaux de bonne qualité disponibles à courte distance de leur colonie. Elles doivent donc se contenter des matériaux disponibles et aller les chercher quelques fois à plus de 1 km ou changer leur site de nidification (Emlen 1952). Cependant, s'il y a une grande disponibilité de différents matériaux à courte distance, les hirondelles semblent bien en mesure d'effectuer un choix et de l'optimiser, tel que nos résultats le démontrent.

Un matériel relativement argileux contenant peu de matière organique est nettement préféré. Ces oiseaux évitent donc des matériaux contenant plus de 10 pour cent de matière organique ce qui est confirmé par l'analyse des nids faite par Kilgore et Knusen (1977). On comprend le choix des hirondelles si l'on considère qu'un matériel argileux favorise la cohésion des particules sédimentaires, une bonne adhésion au substrat et une maléabilité satisfaisante pendant la cueillette et la construction (Kilgore et Knusen 1977). De plus, lorsqu'elle est séchée, l'argile devient très solide et cela est en partie dû à sa forte capacité de rétention d'eau et à la finesse de ses particules. Toutefois, une teneur élevée en argile rend l'ensemble des matériaux cassant, une fois séchés. C'est pourquoi la matière organique stabilise la structure du nid. Une trop grande quantité de matière organique ou une trop faible proportion d'argile aura par contre l'effet de diminuer la cohésion et la solidité des liens entre les particules assurée normalement par la présence de l'argile.

Selon les propriétés du sol, l'action initiale de la matière organique augmente la stabilité de la cohésion entre les sédiments, en partie à cause de l'action de la microflore provenant de matières très fermentescibles (Bonneau et Souchier 1979). Les filaments mycéliens entourent les particules du sol, favorisent l'agrégation et donnent une certaine cohésion aux unités structurales ainsi créées, mais ce sont les polysaccharides et les polyuronides issus de la synthèse microbienne qui apportent cette stabilité structurale (Guckert 1973). En effet, les filaments mycéliens ainsi que les gaines mucilagineuses entourant les corps bactériens sont riches en polysaccharides (Guckert et al. 1974) qui se lient rapidement et intimement aux argiles, plus que ne le font les grosses molécules d'acides humiques. Il y a ainsi formation d'une humine microbienne labile, qui a un rôle fondamental dans la forte augmentation de la stabilité structurale durant cette première phase.

Cette humine est ensuite métabolisée; les polysaccharides disparaissent en grande partie et la stabilité décroît: la première phase de séchage est terminée. Cependant, des produit phénoliques tannants, issus de la décomposition de certains tissus végétaux protègent les polysacharides résiduels (Griffiths et Burns 1972; Thompson et Troeh 1973; Bonneau et Souchier 1979). Il se crée alors des liaisons intenses et très stables entre ces composés organiques et les particules minérales du sol, liaisons favorisées par les alternances de dessiccation et d'humectation, qui conduisent à la formation d'une humine (dérivée d'acide humique) stabilisée (Guckert 1973; Bonneau et Souchier 1979) dont l'action sur la stabilité structurale est bien moins importante, mais plus durable que celle de l'humine microbienne labile.

Les hirondelles doivent donc choisir le matériel qui possède la plus grande proportion d'argile pour obtenir des nids solides. Elles semblent s'assurer une quantité raisonnable de matière organique (pas plus de 10%) à cause de la stabilité des liaisons entre les particules sédimentaires mentionnées plus haut. Rappelons cependant que les proportions de matière organique ne doivent pas être trop élevées compte tenu de la chute de stabilité de la première phase de réaction entre les différentes particules des nouveaux matériaux.

L'importance de l'adhésion, de la cohésion et de la stabilité des nids suspendus comme celui de l'Hirondelle à front blanc semble donc diriger le choix de ses matériaux. Cela expliquerait du moins pourquoi les hirondelles favorisent le site #1 de préférence au site #3 (tableaux 1 et 2). Ces sites sont relativement semblables sauf en ce qui concerne la quantité de matière organique (25,1% au #3; 8,7% au #1). L'explication est aussi logique si l'on compare la composition du nid de l'Hirondelle à front blanc avec celui de l'Hirondelle des granges (*Hirundo rustica*). Cette dernière choisit d'incorporer encore plus de matière organique à son nid (5 à 14%) comme le rapportent Kilgore et Knusen (1977). Le nid de l'Hirondelle des granges est habituellement supporté par une poutre et peut ainsi subir les fluctuations plus grandes de rigidité de la matière organique, lorsque cette dernière est en contact avec de nouvelles particules minérales, au début de la réaction des particules entre elles. Ce nid deviendra par la suite très résistant compte tenu de la stabilité finale qu'apporte cette matière organique. Par exemple, remarquons que les nids d'Hirondelle des granges sont résistants aux chocs et plus élastiques que ceux des Hirondelles à front blanc qui sont relativement cassants.

Parmi les sites naturels potentiels relevés aux environs de la colonie, on peut observer que les sites #6 et 7 sont beaucoup trop sableux même s'ils comportent une certaine proportion de matériel organique. La cohésion entre les particules est due ici presqu'exclusivement à l'humidité, aux ponts et liaisons hydrogènes (Bonneau et Souchier 1979).

Le site #5 relativement semblable au site #3 comporte une bonne quantité de matériel organique (19,2%). Cependant, ce sédiment est très ferreux (il devient rougeâtre lorsque séché), ce qui tend à empêcher la cohésion des particules d'argile et de silt avec les colloïdes humiques et les autres particules en favorisant la formation d'agrégats stables (Bonneau et Souchier 1979). L'utilisation de ce matériel rendrait donc la solidité du nid très précaire.

Les hirondelles semblent donc rentabiliser leur énergie disponible par une optimisation sélective des matériaux appropriés pour assurer une structure cohésive et solide à leur nid. Une fois un site de matériaux choisi, la récolte de boulettes devient plus rapide et plus efficace, bien que la vitesse d'aller ou de retour aux sites semble demeurer constante, quel que soit le matériel choisi. Elle est cependant réduite par le choix d'un site plus rapproché de la colonie. De plus, le temps investi aux interactions entre les oiseaux, surtout sur les sites de matériaux, et celui utilisé pour comparer les sites semble de la même façon réduits et de moins en moins importants.

Pour mieux comprendre les implications énergétiques de la construction et du transport des matériaux, il serait intéressant d'étudier l'effet de la destruction du nid sur le comportement de construction et sur les stratégies déployées par l'oiseau pour rentabiliser ses coûts énergétiques. Une diminution de l'énergie accordée à chaque voyage et une augmentation du nombre de voyage par jour seraient des façons de répondre à ce stress, ou encore en modifiant la structure du nid ou en retardant son achèvement, sans retarder le début de la ponte. En optimisant une de ces stratégies, l'hirondelle pourrait ainsi augmenter son succès reproducteur sans retarder sa ponte, ou maintenir la vitalité requise pour l'élevage des jeunes (Foster 1968; Wilkinson et English-Loeb 1982).

Le genre particulier de construction du nid de l'Hirondelle à front blanc exige une importante dépense d'énergie, estimée à environ 122 Kj, au total (Whiters 1977). Il faudrait donc aussi poursuivre ces recherches pour déterminer comment un tel stress peut affecter la viabilité des oeufs et peut-être même le succès reproducteur selon les dépenses énergétiques de chaque oiseau, en fonction de la taille et de la position du nid construit.

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Site Specificity of Three Species of Lice, Mallophaga, on the Willow Ptarmigan, *Lagopus lagopus*, from Chilkat Pass, British Columbia

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The idea that host preening acts as a selective pressure for morphological and behavioural adaptations of lice, resulting in site specificity on a bird, was examined using the Mallophaga of Willow Ptarmigan, *Lagopus lagopus*. Six adult and five yearling birds collected from Chilkat Pass, British Columbia were infested by three species of lice: the amblyceran, *Amyrsidea lagopi*, and the ischnocerans *Goniodes lagopi* and *Lagopoecus affinis*. This most common (100% infected) and abundant (mean number of lice per infested bird = 28) louse, *G. lagopi*, with its somewhat flattened, short, broad body, large head, short legs and well-developed claws, demonstrated the most localized distribution on the birds while *A. lagopi*, with its more elongate body, narrower head and proportionally longer legs was more equitably distributed. *Lagopoecus affinis* was intermediate. Therefore, the hypothesis that host preening is a major selective pressure on mallophagans was generally supported.

Key Words: Lice, Mallophaga, Willow Ptarmigan, *Lagopus lagopus*, distribution.

Preening is suggested to have played a major role as a selective pressure for morphological and behavioural adaptations of mallophagans (Clay 1949; Nelson and Murray 1971; Marshall 1981). Presumably, because feathers are more varied in structure than hair, philopterid lice on birds show greater diversity in body shapes than do trichodectids on mammals (Marshall 1981). As Clay (1949) pointed out, two extremes in structure (with many intermediates) can be seen that may be related to the sites inhabited by lice on birds, and therefore to the efficacy of preening by the host. Lice with somewhat flattened, short bodies with broad heads, short legs and well-developed claws move more slowly, are relatively sedentary, and live on regions of the host that are difficult to preen (such as the head and neck). Lice with very flattened, elongate bodies with narrow heads, longer legs and weaker claws move more quickly, are more mobile, and live on regions that are more exposed to preening (such as the wings and back).

Mallophagan lice are divisible into two distinct superfamilies, the more primative Amblycera, and the more specialized Ischnocera (Clay 1949). Clay (1949) lists 11 different host groups that are infested by specific genera of "typical" head (short, broad-headed species) and wing (elongated, narrow-headed species) ischnoceran lice, but not on Galliformes. She considered *Goniodes* and *Lagopoecus*, which are common on Galliformes, to be unspecialized, although the evolutionary history of *Goniodes* has led to Galliformes each having an allopatric species of louse. In addition, Clay (1949) asserts that the two characters of ischnoceran lice most responsible for sexual isolation of their populations were differences in the shapes of the abdomens and sexual dimorphism of antennae. Most "wing" lice have sexually dimorphic antennae whereas in "true" head lice, this is rare. Because *Goniodes lagopi*, a common ischnoceran on Willow Ptarmigan, *Lagopus lagopus* (*see* Emerson 1951; Malcomson 1960), has extremely dimorphic antennae, and the other mallophagans on ptarmigan are hypothesized to be unspecialized, we might predict that there would be no evidence for distinct habitat specialization (site specificity) in the distributions of lice on this host.

Willow Ptarmigan from Chilkat Pass, British Columbia were infested with a mallophagan community comprised of three species: *Amyrsidea lagopi*, *Goniodes lagopi*, and *Lagopoecus affinis*. Analysis of the distributions of lice on different regions of 11 birds corroborated the hypothesis that lice are not adapted for feeding or living on specific feather types, but predominate in regions where they are morphologically and behaviourally modified to limit losses by preening. Although not differentiated into the extremely specialized "head" and "wing" ecotypes identified by Clay (1949), a pattern of differential habitat preference was demonstrated.

Materials and Methods

Willow Ptarmigan (5 yearlings = age 10 to 13 months, 6 adults) were collected by S. J. Hannon, Department of Zoology, University of Alberta in April, May, June and July, 1987, at Chilkat Pass, British Columbia (59° N, 137° W), as part of a study of their reproductive ecology and population dynamics. Birds were bagged individually and frozen within two to five hours after collection. In the laboratory, birds were thawed and skinned. Skins were divided into seven regions: head, back, breast, right and left wings, legs and tail. Each region was bottled in warm water with detergent, shaken vigorously for approximately 30 s, and then the fluid was sieved (425 μm aperture) to collect lice. Wet skin sections were combed with forceps under a magnifying lamp to collect any adhering lice. Mallophagans were stored in 70% ethanol, cleared in 10% KOH and mounted in Hoyer's clearing and mounting agent. Sex and instar (adult or nymph) of lice were recorded. Eggs of lice were not collected or counted. Mounted specimens were identified using keys and information in Clay (1938, 1940), Keirans (1967), and Price and Elbel (1969). Body measurements of lice were made from mounted specimens under a compound microscope using an ocular micrometer and drawing tube. Voucher specimens were deposited in the University of Alberta Parasite Collection, UAPC 11259 to 11273, and UAPC 11284 to 11297.

Results

All 11 ptarmigan were infested by at least two of three species of Mallophaga (*Amyrsidea lagopi, Goniodes lagopi,* and *Lagopoecus affinis*). The total number of lice on an individual bird ranged from 12 to 69, with a median of 40 (mean = 40.27). The most prevalent (100%) and abundant (mean number per infested bird = 28) species was *Goniodes lagopi.* It was also, however, the least diversely distributed louse (Shannon-Waver H = 2.11, equitability E = 0.75), localizing on the chest (41% of the population), back (31%) and head (15%) (Table 1). Only 13% of the *G. lagopi* occurred on the extremities, with the wings being the least preferred site (2% on the left and 2% on the right wings). The other two species of lice, (*Amyrsidea lagopi* and *Lagopoecus affinis,* although less abundant (mean number per infected bird = 5 and 7 respectively), were more widely and evenly distributed on the birds (H = 2.40, 2.81 and E = 0.85, 0.84 respectively). Like *G. lagopi,* the chest was the most preferred site of infestation,but both occurred commonly on the wings (18% for *A. lagopi,* 31% for *L. affinis*).

Distribution appeared to be related to morphology. The three species of lice demonstrated a gradient in morphology from those with a broad head, round body with relatively short legs and well-developed claws (*G. lagopi*), to *A. lagopi*, which is relatively elongated with a narrower head and longer legs (Table 2, Figure 1). *Lagopoecus affinis* is intermediate in morphology.

The three species of lice showed no age specificity; adult and yearling birds were equally parasitized. However, there was some indication that sex of host was important. Male Ptarmigan had a mean of 56 lice per bird while the mean for females was 37 per bird. This difference could not

Table 1. Distribution of three species of Mallophaga on Willow Ptarmigan (*Lagopus lagopus*).

	Amyrsidea lagopi			*Lagopoecus affinis*			*Goniodes lagopi*		
Site	no.	%	rank	no.	%	rank	no.	%	rank
Chest	23	41	1	26	34	1	127	41	1
Back	9	16	3	13	17	3	97	31	2
Head	5	9	5	12	16	4	47	15	3
Rt. Wing	7	12	-	9	12	-	5	2	-
Lf. Wing	3	5	-	15	19	-	5	2	-
Wings	10	18	2	24	31	2	10	3	5
Tail	2	4	6	0	0	6	8	3	6
Legs	7	12	4	2	3	5	22	7	4
Total number of lice[1]		56			77			311	
Diversity[2]		2.40			2.81			2.11	
Equitability[3]		0.85			0.84			0.75	
Prevalence (%)		36			100			100	
Mean Intensity		5.1			7.0			28.3	

[1] Includes total for wings only.

[2] Shannon-Weaver Index of Diversity, $H = -\Sigma(p_i)(\log_2 p_i)$.

[3] Equitability = H/H_{max}.

TABLE 2. Selected morphological characteristics (in micrometers) of three species of Mallophaga from Willow Ptarmigan (*Lagopus lagopus*).

	Amyrsidea lagopi		*Lagopoecus affinis*		*Goniodes lagopi*	
	male	female	male	female	male	female
Number measured	14	20	16	20	20	20
$\bar{x}$ Head Width	756	805	554	633	1234	1325
$\bar{x}$ Length	2460	2912	1870	2242	2863	3405
$\bar{x}$ Width	903	1074	762	881	1603	1711
$\bar{x}$ Length of 2nd Leg	932	1048	556	619	1083	1102
Head/Width	0.84	0.75	0.73	0.72	0.77	0.77
Length/Width	2.72	2.71	2.46	2.55	1.79	1.99
Leg/Width	1.03	0.98	0.73	0.70	0.68	0.64

be demonstrated statistically, however, because only two of the 11 birds sampled were male. S. J. Hannon (personal communication) observed that female Willow Ptarmigan spend more time preening than males, which might account for differences in number or distribution of lice.

Adult lice of all three species predominated, but nymphs formed a larger part of the population of *G. lagopi* (42%) than in the other species (4% for *A. lagopi*, 1% for *L. affinis*).

Discussion

As suggested by Clay (1949), Nelson and Murray (1971) and Marshall (1981), the species of louse with a broad head, rounded body and short legs (*G. lagopi*), appears to be specialized for inhabiting regions of the host that are sheltered from preening; i.e., head and neck. Those species that were narrower, more elongated, with longer legs and presumably more mobile (*L. affinis* and particularly *A. lagopi*), were more broadly distributed on the Willow Ptarmigan. Strilchuk (1976) found a similar pattern for four different species of Mallophaga on Mallard ducks (*Anas platyrhynchos*). On Willow Ptarmigan, however, the breast was the most heavily infested site for all three species of lice. This site probably is one that is heavily preened but densely feathered, and the occurrence of lice there may represent a post-mortem migration to a warmer region. Ash (1960) noted that amblyceran lice (such as *Amyrsidea*) are extremely active blood feeders that readily transfer to new hosts. Adults and nymphs of *Amyrsidea* sp. from pheasants were distributed over the whole of the body, although the greatest number were found concentrated about the ventral surface of the bird at the base of the neck (Ash 1960). The ischnoceran lice (e.g. *Goniodes* and *Lagopoecus*) tend to feed on feathers and commonly are found attached to feathers after death of the host. Overall, it does appear that preening is a significant factor involved in the distribution of lice on Willow Ptarmigan.

However, other factors may be involved in defining habitat use by the lice. Although too few birds were sampled to provide any conclusive evidence, there were some indications that interactions between species may occur. *Goniodes lagopi* was the largest louse on Willow Ptarmigan and there was a negative correlation (although not statistically significant) between it and numbers of the other species ($r = -0.300$, $df = 10$, $P > 0.05$). Similarly, 63% of the *L. affinis* that infested the wings of Willow Ptarmigan occurred on one wing while 70% of *A. lagopi* occurred on the other, thus demonstrating complementary distributions. Again, however, a greater sample of hosts that could be used to examine distributions in concurrent and monospecific infestations (or experimentally infested birds), would be necessary to eliminate interaction as a factor involved in affecting distributions.

Clay (1949) indicated that the environment of Mallophaga is formed by the chemical composition and physical structure of the feathers, the texture of the skin and certain physiological characters of the host such as temperature and body secretions. Murray (1986) discussed pelage of mammals as a habitat for lice and pointed out how important microclimatic factors, such as skin temperature, can be in determining distributions. Willow Ptarmigan are boreal birds that change colour from white with a black tail in winter, to brown with white wings in summer. Possibly, temperatures over the body surface change with changes in colouration and differential peripheral blood flow, and lice may move accordingly. Seasonal collections of birds with data on plumage colour in relation to numbers and distributions of mallophagans would be necessary to deduce the importance of microclimate in determining locations of lice.

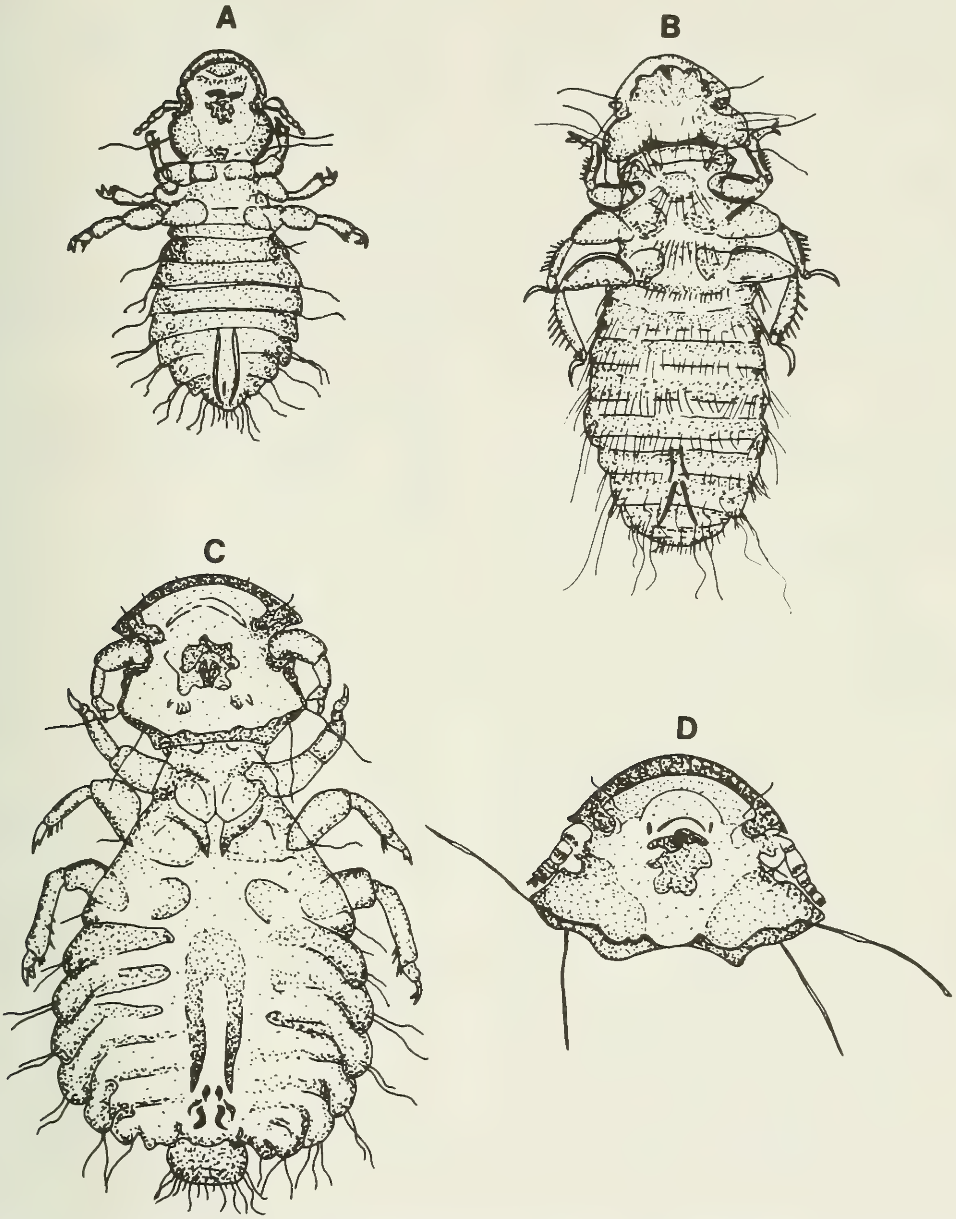

FIGURE 1. Three species of Mallophaga found on Willow Ptarmigan (*Lagopus lagopus*). A. *Lagopoecus affinis* male; B. *Amyrsidea lagopi* male; C. *Goniodes lagopi* male; D. *G. lagopi* female. (All are drawn to the same scale).

Acknowledgments

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Asynchronous Hatching Pattern of Common Loons, *Gavia immer*, in Northwestern Ontario

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Croskery, Peter Ross. 1989. Asynchronous hatching pattern of Common Loons, *Gavia immer*, in northwestern Ontario. Canadian Field-Naturalist 103(4): 589–592.

A total of 205 territorial loon pairs (*Gavia immer*) on 30 lakes were monitored for a four-year period to determine the degree of synchrony in hatching. Hatching occurred over periods of 39 to 46 days with mean hatch date and total young hatched very consistent in all years. For a Common Loon population, asynchronous hatching appears to be favoured since it reduces direct competition on size selected food items within the loon's aquatic habitat.

Key Words: Common Loon, *Gavia immer*, hatch, asynchrony, Ontario.

Although numerous studies have examined nesting success and young production in Common Loons (*Gavia immer*), none have given specific attention to the pattern of hatching. Munro (1945) stated that egg-laying was initiated from the second last week of May until the third week of June, but did not comment on hatching. Barr (1973) found hatching occurred between mid-June and early August with the peak hatch, including renests, occurring in the third and fourth weeks of July. Fox et al. (1980) reported a strong correlation between egg-laying and ice-out, yet Sutcliffe (1980) stated that egg-laying began from 13 to 54 days after territorial establishment but made no reference to ice-out.

For other species, hatching is well documented, and both food availability and length of the summer are important factors regulating timing of hatching. Some species adjust hatching so that young are born when food availability peaks (Orians 1971; Sealy 1980; Sjoberg and Danell 1982). It is thought that most boreal bird species produce young early in the breeding season so that young will be in good condition by fall to undertake southward migration.

When the terms synchrony and asynchrony are used in reference to avian nesting biology, they usually refer to either the hatching pattern of individual eggs within a specific nest or, in the case of colonial birds, the overall hatching pattern of all nests in the colony. In this paper, I apply the terms to a population of Common Loons, a species known for its' small clutch size and strong territorial behavior. It is in this context that this paper examines the pattern of young hatching.

Methods

The study was conducted in a 200 sq. km area located in northwestern Ontario near Ignace (approximately 49° N, 91° W). Lakes (n = 30) within the study area ranged in size from 6.0 to 5314 ha. Each lake supported at least one resident pair of Common Loons.

Each lake was surveyed every 10 days during the open water season (May-September) in all four years of the study (1983-1986). All loons sighted were mapped and young present were aged.

Aging of young was done by comparing them to young of known age. Known ages were obtained by monitoring nests and following, through the summer, the growth of the young that hatched. Comparisons were based on size, coloration, feather development, and behavior. Any young seen for the first time at ages of more than two weeks were not included in assessment of hatching as they could not be aged with enough precision. (This represented fewer than 10 per cent of young in any given year.)

Common Loons most frequently have a clutch size of one or two eggs. Where two eggs exist, the second hatches within 24 hr of the first. For this study, all nests were treated as single egg hatches. This does not introduce any bias in hatching data since in only one instance did the second egg fail to hatch after the first had. I refer to chicks as "chick groups" in consideration of this concern.

Hatch date was recorded by both calendar date and number of days from ice-out. Ice-out was established as the first day Camp Lake was 100 per cent ice-free. Camp Lake was selected as the standard as it was central within the study area, was always the first of the study lakes to become completely ice-free, and because it was convenient to monitor. In all years of this study, all lakes within the study area were ice-free within one week of ice-out on Camp Lake.

Results

The earliest ice-out within this study occurred during the third week of April 1986 (Table 1), an

TABLE 1. Comparisons of Common Loon hatch-out, 1983-1986, Ignace, Ontario.

	1983	1984	1985	1986
Number of Territories	205	205	205	205
Number of Young Groups	55	48	61	47
Ice Out Date	8 May	22 April	27 April	18 April
X Hatch Date	6 July	5 July	1 July	28 June
First Hatch	20 June	14 June	20 June	11 June
Latest Hatch	29 July*	29 July	28 July*	22 July
X Hatch/Day	1.3	1.0	1.6	1.1
Range (Days)	40	46	39	42

*Active nests with eggs still being incubated.

unusually warm early Spring. In most years, ice-out occurs during the last week of April or the first week of May. Each year's first loon chicks appeared during the middle of June and hatching continued to occur over the next 39 to 46 days. The annual number of chick groups that were sighted before the chicks reached two weeks of age ranged between 47 and 61. Within the study area, slightly more than one chick group hatched each day (1.0-1.6 = Mean Hatch/Day). The statistic, Mean Hatch/Day has validity in this study since the same number of territories (n = 205) were occupied and monitored in all years.

Size of the resident loon population of any lake showed a strong correlation with lake shoreline length (r = 0.958). Small lakes with less than 3 km of shoreline had a single pair. Larger lakes with some shorelines in excess of 100 km supported numerous loon pairs. Examination of hatching on individual lakes did not show synchrony. Raleigh Lake, which had the highest number of young produced, showed some clumping of hatching in 1985, but this pattern was not consistent in other years of the study (Figure 1). The geographical configuration of Raleigh Lake (numerous isolated bays) was such that pairs, although from the same lake, were visually isolated from each other. Where loon pairs were visible to each other, as on Snowstorm and Pike lakes, clumping of hatching was not noted and asynchrony of hatch was most pronounced.

Discussion

Although there was a difference of 20 days between the earliest (1986) and latest (1983) ice-out dates, a difference of similar magnitude was not evident for either first hatch or mean hatch date. Earlier ice-out does appear to result in an earlier first hatch but appears to have no influence on mean hatch date. This would suggest that although loons are quick to occupy territories following ice-out, the onset of nesting by most pairs is influenced most greatly by other factors.

From a feeding standpoint, the asynchronous hatching seen in Common Loons can be accommodated by the nature of the medium in which the birds forage. Whereas for terrestrial migratory bird species, the onset of cooler temperatures coincides with a sharp decline in prey items, fall weather has no comparable effect on the prey available for Common Loons. Lakes within the study area remain ice-free and suitable as loon habitat until mid-November. The departure of terrestrial avian migrants usually precedes loon departures by a month. The longer availability of food for young loons greatly extends the young-rearing season and reduces the need to produce young as early as possible in the breeding season.

Birds have developed a variety of different mechanisms for dealing with predation. Two of these methods are to produce numerous young all at the same time, thus ensuring some survival through sheer numbers, or produce young at different times so that predators don't cue in on them as particular seasonal prey items. The asynchronous hatch of loons would appear to conform to the latter approach.

The hatching pattern observed in this study is probably the best system for Common Loons. The lack of synchrony in hatch ensures that a lake is not overcrowded with a large group of predators, all seeking prey items of the same size at the same time. By having new predators (young) of different ages, and therefore of different sizes, the pressure on prey items at any time is dispersed over a wider range of prey sizes. As the young loons grow, they shift their predation pressure to larger prey items. In effect this system reduces the competition between young loons for food and ensures that predation is scattered over the range of prey size rather than focused exclusively on a single prey item.

Common Loons are reported to be mainly piscivorous, although they will utilize other food items. If young loons were all the same size, feeding on the same-sized prey, a prey item such as a single

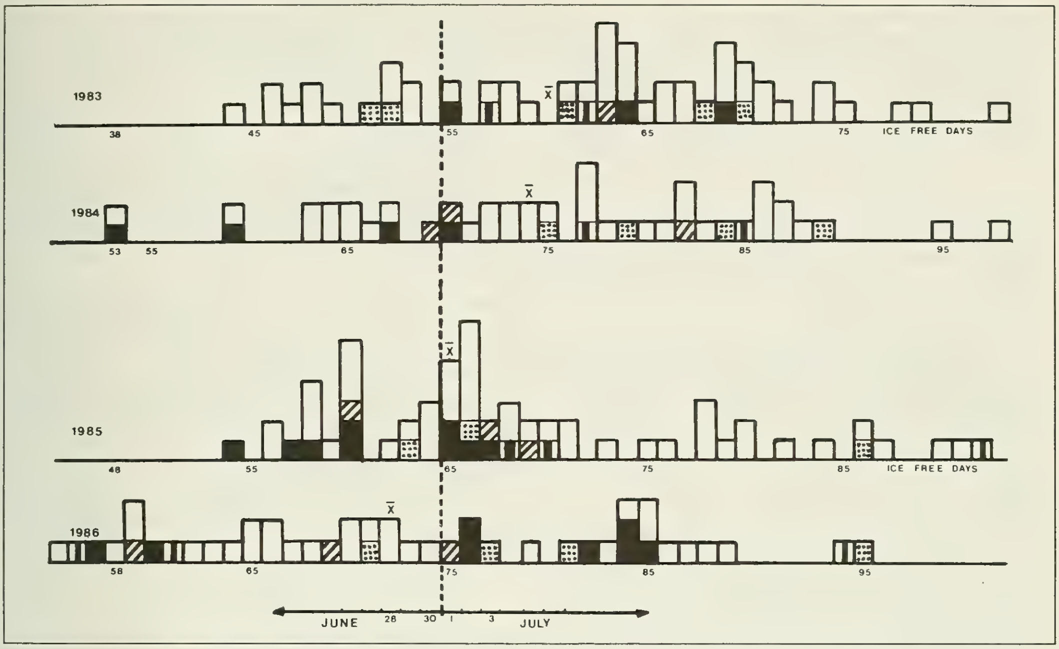

FIGURE 1. Hatch-out dates for Common Loons, *Gavia immer*, near Ignace, Ontario 1983-1986. (Specific lakes: Raleigh ■ ; Pike ▨ ; Snowstorm ◫ ; Arethesa ▦ .

year-class of fish would be subjected to heavy summer-long predation. As the young fish grow, so do the loon chicks, and thus the fish continue as the preferred prey size selected by the young loons. As different species of fish hatch at different times in the spring and grow at slightly different rates, the chance of all young loons targetting the same single species of fish as their preferred prey item would increase. This could seriously affect the status of that species in the lake's overall fish community, or lead to reduced survival of loon chicks as that prey item became reduced.

It has been argued that territorial behavior minimizes competition among young (Payne and Groschupf 1984), but for Common Loons that argument applies only to space. The prey items of loons are highly motile and may not stay in a specific loon territory. Studies of young-of-the-year Yellow Pickerel (*Stizostedion vitreum vitreum*) and Yellow Perch (*Perca flavescens*) have shown the open water movement of these young fish (Houde 1969a, 1969b). As wind-generated currents move these young fish from one loon territory to another, they would be exposed to differing predation pressure, particularly if the predator was selecting prey items based on size.

Asynchronous hatch within a single nest is well documented for a variety of species (Nuechterlien 1981; Inoue 1985). This mechanism is thought to provide an advantage by ensuring a minimal number of young with high fitness are produced, an adaptive response to unpredictable food shortages. It also ensures the formation of a hierarchy among nestlings (Lack 1954). In poor food years, a minimal number of young fledge. The same survival benefits would apply to loons, particularly if we consider an individual lake as a "nest area". Young loons are tied to their natal lake, and therefore any adaptation that increases their food availability would be in the best interest of the birds.

I conclude that Common Loons in northwest Ontario exhibit an asynchronous hatching pattern. With this asynchrony, multiple-territory lakes have a reduced competition for food by young as young of different pairs are feeding on different sized food items during a particular time period. Unlike territorial avian populations which are influenced by the end of summer, loons feed in a stable environment where climate is not as great an influence. This prolongs the young-rearing season and allows hatch to occur at later dates. Within the loon population of the study area, both mean hatch date and total young hatched per year were very consistent. This probably reflects a stable forage base from year to year and maybe a good indicator of loon habitat quality.

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Notes

First Canadian Record for the Clam Shrimp *Caenestheriella belfragei* (Crustacea: Conchostraca)

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Donald, David B. 1989. First Canadian record for the clam shrimp *Caenestheriella belfragei* (Crustacea: Conchostraca). Canadian Field-Naturalist 103(4): 593-594.

The freshwater clam shrimp, *Caenestheriella belfragei* (Packard 1871), was collected from Mamawi and Claire lakes in Wood Buffalo National Park, Alberta, during summer 1971 to 1973. These records are the first for Canada, and extend the known range of this species north by over 1400 km.

Key Words: Conchostraca, clam shrimp, *Caenestheriella belfragei*, Alberta, first record.

The conchostracan or clam shrimp, *Caenestheriella belfragei* (Packard 1871), inhabits shallow ponds and lakes in west-central United States and Oregon (Figure 1) (Edmondson 1959; Pennak 1978). From 1971 to 1973, *C. belfragei* was collected by D. A. Fernet or D. B. Donald from Mamawi and Claire lakes in the Peace-Athabasca Delta, Wood Buffalo National Park, Alberta (58° 35′N, 111° 25′W and 58° 35′N, 112° 00′W, respectively). During summer 1971 and 1972, this species was common in metre-square trawl samples taken from both lakes. These site records were the first for Canada, and extend the known range of this species north by over 1400 km.

Mamawi and Claire lakes are large (168 and 1455 km^2, respectively), shallow (maximum depth about 1.5 and 3.0 m, respectively) freshwater habitats. Water level, and thus lake depth varies from year to year, and in low water years, large expanses of the lake bottom are exposed to the atmosphere (Peace-Athabasca Delta Project Group 1973). Total dissolved solids for the two lakes ranges from 113 to 5190 mg/L, depending on the site and season, and mean values for spring and summer were 381 mg/L for Lake Claire and 232 mg/L for Mamawi Lake.

C. belfragei was an important food of Goldeye (*Hiodon alosoides*) in the Mamawi-Claire lake system from late June to August, 1971 to 1973 (Donald and Kooyman 1977). Their occurrence in fish stomachs coincided with the seasonal life cycle of this species in the Delta. However, stomach samples of Goldeye collected from the same area in 1947-1948 did not contain conchostracans (Kennedy and Sprules 1967), and they may have been absent or rare in Mamawi-Claire lakes during these years. This discrepancy in occurrence between the 1940s and the 1970s can be explained by either a colonization or a "critical environmental conditions" hypothesis.

C. belfragei may have recently colonized the Peace-Athabasca Delta. This species occurs principally south of the limits of Pleistocene glaciation in the interior plains of North America (Figure 1), and apparently has limited capability for dispersion as indicated by its absence from comparable regions in western Canada. However, eggs of *C. belfragei* may have been carried to the Delta either on or within waterfowl sometime after the late 1940s. Phyllopod eggs can pass through the gut of waterfowl in a viable condition (Procter 1954). Certainly, several hundred thousand waterfowl (ducks, geese, swans) primarily from the Central and Mississippi flyways stage in the Delta each spring (Peace-Athabasca Delta Project Group 1973). However, if *C. belfragei* was present in the Delta in the 1940s, its absence from fish stomachs could be explained by the occurrence of unfavourable environmental conditions for this species at that time.

The eggs of *C. belfragei* may require critical chemical or physical environmental conditions before they can develop and hatch, and these critical conditions may not have been met in 1947-1948. Eggs of the conchostracan, *Eulimnadia antlei*, are stimulated to hatch by water of low salinity, light, and drying (Belk 1972), and *Caenestheriella setosa* only hatches at tempera-

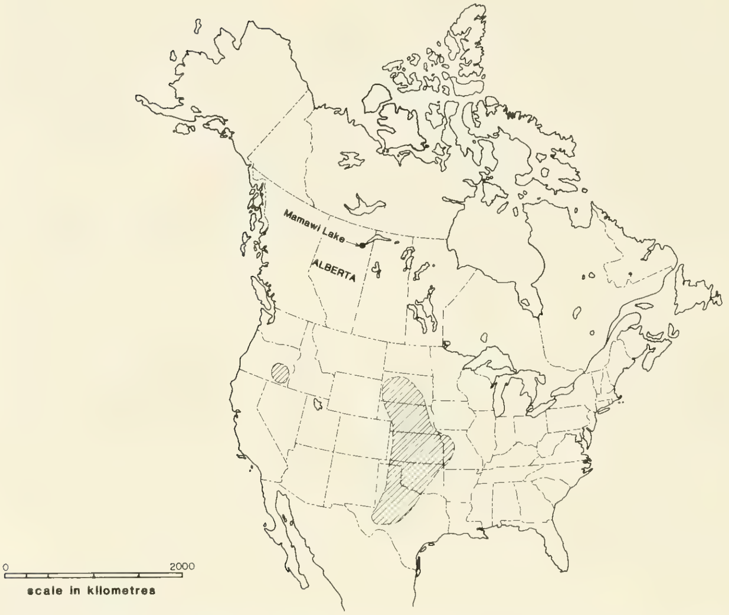

FIGURE 1. The geographic distribution of *Caenestheriella belfragei* (*adapted from* Edmondson 1959; Pennak 1978) showing the position of the Mamawi Lake locality relative to the previously documented range of the species.

tures from about 20°C to 35°C (Belk and Belk 1975). Eggs of Anostraca or fairy shrimp, another Order of freshwater phyllopod that inhabit shallow water habitats, must also be subjected to critical environmental requirements before they can hatch (Broch 1965; Belk 1977; Donald 1983). For several species of fairy shrimp, exposure to the atmosphere stimulates development or hatching of eggs. The low water years of 1968 to 1971 in the Delta (Peace-Athabasca Delta Project Group 1973) may also have subjected eggs of *C. belfragei* to favourable environmental conditions, and caused an increase in population density at this time.

Specimens of *C. belfragei* from Mamawi Lake were deposited in the National Museum of Natural Sciences, Ottawa, Canada (Catalogue Number NMCC1987-0387). Taxonomic status of these specimens was based on the opinions of the author and D. Belk who compared the Mamawi Lake material with specimens collected from the southern United States.

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Test of Nest Box Preferences of Eastern Bluebirds, *Sialia sialis*, and Tree Swallows, *Tachycineta bicolor*

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Lumsden, Harry G. 1989. Test of nest box preferences of Eastern Bluebirds, *Sialia sialis*, and Tree Swallows, *Tachycineta bicolor*. Canadian Field–Naturalist 103(4): 595–597.

Choice by Eastern Bluebirds, *Sialia sialis*, and Tree Swallows, *Tachycineta bicolor*, of nest boxes designed specifically for each was recorded in 1985-87 at two study areas in Ontario. All the bluebirds used the boxes designed for them and Tree Swallows used the boxes designed for them over four times as often as the bluebird boxes. House Wrens, *Troglodytes aedon*, did not show any preference. Too few Black-capped Chickadees, *Parus atricapillus,* House Sparrows, *Passer domesticus,* and Great-crested Flycatchers, *Myiarchus crinitus*, used the boxes to indicate a preference. Ontario Eastern Bluebirds chose boxes with larger entrances than those in Manitoba.

Key Words: Eastern Bluebirds, *Sialia sialis*, Tree Swallows, *Tachycineta bicolor*, House Wrens, *Troglodytes aedon*, Black-capped Chickadees, *Parus atricapillus*, House Sparrows, *Passer domesticus*, Great-crested Flycatchers, *Myiarchus crinitus*, nest boxes, competition, Ontario.

Characteristics of next boxes preferred by secondary cavity-nesting birds were identified by an earlier series of experiments in which one feature was varied in sets of 2 or 3 boxes mounted together (Lumsden 1986). This note reports on the results of further tests in which the features favoured by Eastern Bluebirds (*Sialia sialis*) were combined in one box type and those favoured by Tree Swallows (*Tachycineta bicolor*) in another. The objectives of these tests were to measure acceptance and see if competition among species could be reduced.

Materials and Methods

In accordance with the earlier results (Lumsden 1986), the bluebird box had a floor that measured 10 × 10 cm, an entrance 44 mm in diameter, a depth from the bottom of the entrance to the floor of 14 cm. The Tree Swallow box had a floor of 15 × 15 cm, an entrance 35 mm in diameter, and a depth of 12 cm. Externally all boxes were stained pale grey-brown and all were painted white inside. Sheeting grade plywood 1.3 cm thick was used and no nest material was provided.

The boxes were mounted singly 1.5 m above the ground on posts spaced 45+ m apart facing south. Bluebird and tree swallow boxes alternated and each year were switched so that a post carrying a bluebird box in 1985 carried a tree swallow box in 1986 and a bluebird box in 1987. Fifty-nine boxes were placed in 1985, 55 in 1986 and 34 in 1987. A choice by a species was recorded only when a nest was built and one or more eggs laid. For a description of the study areas at Anten Mills and Aurora see Lumsden (1986).

Results

The results of these tests are summarized in Table 1. All the bluebirds chose the boxes which combined the features they preferred in the earlier tests (Lumsden 1986). None used the Tree Swallow boxes ($P < 0.001$, Table 1). Tree Swallows used the boxes designed for them over four times as often as the bluebird boxes ($P < 0.05$, Table 1). House Wrens (*Troglodytes aedon*) did not discriminate between the boxes offered ($P > 0.005$, Table 1), and probably had little influence on the choices by Bluebirds and Tree Swallows because they used approximately equal numbers of each kind of box. Because they also nest later they did not interfere with the choices of Tree Swallows and first nests of bluebirds. House Sparrows (*Passer domesticus*) used only one box at Aurora during the three years of tests.

The Black-capped Chickadees (*Parus atricapillus*) usually dig their own nesting cavity in rotten wood, but six used nest boxes at Anten Mills (in which five laid eggs) in 1986 and 1987. The first nests were started in early May before Tree Swallows and House Wrens had started to build. Too few Black-capped Chickadees used the boxes to give any indication of preference. They are unlikely to offer much competition with other cavity nesters because of the rarity of their use of boxes.

In 1986 two Great-Crested Flycatchers (*Myiarchus crinitus*) nests were in Tree Swallow boxes. They chose those in which the entrances had been enlarged by the gnawing of Chipmunks (*Tamias striatus*). Like the Black-capped Chickadee, this species, which nests relatively late, is not likely to compete with bluebirds.

Munro and Rounds (1985) showed that temporal separation in breeding was important in reducing competition at least in the early part of the breeding season for some of the species they studied in Manitoba. In this Ontario study,

TABLE 1. Choice of bluebird and Tree Swallow nest boxes by six cavity nesting species.

Species	Number of nests in Bluebird Box	Number of nests in Tree Swallow Box
Eastern Bluebird	10	0
Tree Swallow	3	13
House Wren (*Troglodytes aedon*)	12	11
House Sparrow (*Passer domesticus*)	0	1
Black-capped chickadee (*Parus atricapillus*)	2	3
Great-Crested Flycatcher (*Myiarchus crinitus*)	0	2
Unoccupied	46	45
Total Boxes	73	75

Eastern Bluebird = Binomial Tables $P < 0.001$.
Tree Swallow = Binomial Tables $P < 0.05$.

Eastern Bluebirds generally started their first nests in late April (earliest record: 4 eggs, 19 April) before Tree Swallows arrived at this site and four weeks before House Wrens, and were thus largely free of competition for their first nesting attempts. In contrast, while they did not discuss competition, Munro and Rounds (1985) found that both Eastern Bluebirds and Tree Swallows in Manitoba initiated their nests during the third week of May, and about three weeks later than Mountain Bluebirds (*Sialia currucoides*).

For Tree Swallows and Mountain Bluebirds, Munro and Round (1985) found that intrinsic characteristics of nest boxes or their placement were more important than the surface cover of the area in identifying choices. For Eastern Bluebirds, their stepwise discriminant function analyses showed first a choice of boxes associated with the greatest availability of grass and wooded pasture, with a large component of shrub pasture. They avoided long grass and fallow. Less important but still significant was a choice of boxes with small entrance holes (Used: $\bar{x} = 39.3 \pm 5.3$ mm: Unused: $\bar{x} = 41.6 \pm 5.7$ mm). Eastern Bluebirds in the Manitoba study differed from those in southern Ontario in that the latter preferred larger entrances (44 mm in diameter) over smaller (35 mm; Lumsden 1986).

It is likely that the preferences for cavity features of local populations are shaped by competition and may vary from place to place. Thus, Mountain Bluebirds in Manitoba used the nest boxes with the largest entrance hole diameter. Because they nested earlier than Eastern Bluebirds, they appeared to have excluded the latter from using boxes similar to those favoured in Ontario.

The Eastern Bluebird boxes in Ontario had entrances 44 mm in diameter, but none were used by European Starlings (*Sturnus vulgaris*) although large enough to admit them. Starlings prefer dark boxes with black interiors and avoid white (Lumsden 1976). Although Starlings were common on the study areas and nested in boxes designed for American Kestrels (*Falco sparverius*) and Wood Ducks (*Aix sponsa*), they appeared reluctant to use the bluebird boxes. It seems likely that the light interiors of the boxes freed the Eastern Bluebirds from competition with Starlings.

Tree Swallows showed a significant preference for the boxes designed for them, but occasionally used a bluebird box although many unoccupied Tree Swallow boxes were available. Tree Swallows were relatively undiscriminating in their choice of box features in earlier experiments (Lumsden 1986). Munro and Rounds (1985) also found great variability in nest box selection by Tree Swallows in Manitoba. However, they found that Tree Swallows avoided sites with wooded pasture which were favoured by Eastern Bluebirds and chose sites with long grass which were avoided by Eastern Bluebirds.

House Wrens can create problems when they vandalize the nests of other cavity-nesting species. Because the male wrens build more than one nest and probably use most of the suitable cavities (or boxes) within their territories, they can provide formidable competition for other species. House Wrens, however, chose more shrub and tree cover in their territories than the Bluebirds and Tree Swallows in Manitoba and no House Wrens nested more than 30 m from a tree or tall shrub (Munro and Rounds 1985). Box location may be the most effective means of reducing competition between wrens and other species.

House Sparrows (*Passer domesticus*) can be persistent and vigorous competitors with other cavity nesters. Gowaty (1984) presented circumstantial and correlational evidence of House Sparrows killing adult Eastern Bluebirds and observed the destruction of a brood. In this study only one box at Aurora was occupied by House Sparrows. This box was located within 330 m of dwellings and bird feeders. At Anten Mills all the boxes were placed more than 600 m from houses and a stable, and none was used by House Sparrows. Munro and Rounds (1985) in Manitoba found that House Sparrows favoured boxes with small entrances 30-38 mm in diameter. They stated that House Sparrows cannot be excluded from boxes by design features that allow ready occupation by more desirable species. However, House Sparrows can be excluded from Tree Swallow boxes by cutting oval entrances 27 mm wide × 22 mm vertical (A. J. Erskine, personal communication). Munro and Rounds found that Mountain and Eastern Bluebirds tended to nest more than 400 m from buildings whereas House Sparrows nested within 400 m of buildings. The inference is obvious, to favour Eastern Bluebirds and reduce competition from House Sparrows, boxes should be placed in areas remote from human habitation.

This test demonstrated that both Eastern Bluebirds and Tree Swallows would choose boxes designed especially for them. Competition may be further reduced by placing bluebird boxes in areas with grassland, pasture with shrubs or trees; Tree Swallow boxes are best placed in extensive open areas with long grass; House Wren boxes should be located in wooded or shrubby areas and not more than 30 m from a tree or tall shrub; House Sparrow boxes may be placed within 400 m of a stable or houses.

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Munro, H. L., and **R. C. Rounds.** 1985. Selection of artificial nest sites by five sympatric Passerines. Journal of Wildlife Management 49(1): 264–276.

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The Nomenclatural Status and Type Locality of the Yellow Warbler Subspecies *Dendroica petechia aestiva* (Gmelin) (Aves: Parulinae)

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Browning, M. Ralph. 1989. The nomenclatural status and type locality of the Yellow Wabler subspecies. *Dendroica petechia aestiva* (Gmelin) (Aves: Parulinae). Canadian Field-Naturalist 103(4): 597–599.

The name *aestiva* Gmelin, 1979, is based on the bright population of Yellow Warbler, *Dendroica petechia*, found in southeastern North America, contra Oberholser (1974). Restricted type localities of birds based on Brisson with the original locality "Canada" should be given uniformly as Québec, Québec.

Key Words: *Dendroica petechia aestiva*, Yellow Warbler, type locality.

Five subspecies of the Yellow Warbler, *Dendroica petechia*, are recognized as breeding in Canada and the United States (Lowery and Monroe 1968). Two are in eastern North America. A dark subspecies, *D. p. amnicola* (Batchelder 1918), breeds from north-central Alaska to Labrador, southward to northeastern British Columbia and to south-central Quebec and Newfoundland. A paler and brighter subspecies *D. p. aestiva* (Gmelin 1789) has a breeding range south of *amnicola* that occupies southeastern Canada and the eastern United States (cf. A.O.U. 1957; Lowery and Monroe 1968).

In discussing the nomenclature of the eastern subspecies of the Yellow Warbler, Oberholser (1974: 1000) concluded that the references cited by Gmelin (1789) in the original description of *aestiva* referred to the dark northern subspecies and that the paler southern subspecies therefore should be known by the name *D. p. flava*. Raveling and Warner (1978), in a study of the geographic variation in certain eastern populations that represent both *amnicola* and *aestiva*, raised the need for further clarification of the nomenclature and taxonomy of the species to allow proper allocation of certain populations to subspecies. My investigation of the basis for the name *aestiva* reveals that the nomenclature of the eastern subspecies (*sensu* Lowery and Monroe 1968) requires no change.

The first name proposed for what is now *D. p. aestiva* was *Motacilla canadensis* Boddaert (1783). This name is preoccupied by *Motacilla canadensis* Linnaeus, 1776, a name used for two species of Parulinae by Linnaeus, neither of them applicable to *D. petechia*. Gmelin (1789: 996) based *Motacilla aestiva* on Brisson (1760: 492, Plate 26, Figure 3) and on "Figuier de Canada" from Daubenton's Plate 58, Figure 2. Three other references cited by Gmelin have as their basis Daubenton's Plate 58, Figure 2. The three works include Pennant (1784-85: 402, 409), Latham (1783: 515), and Buffon [and Montbeillard] (1782: 285). [According to Cowan (1968), Volume 5, usually attributed solely to Buffon, was jointly authored.]

Daubenton's Plate 58, Figure 2, is of an adult male Yellow Warbler in breeding plumage. The bird is dorsally yellow and therefore similar to examples of the species from southeastern Canada and the eastern United States. The forehead is yellow and ventrally the bird is bright yellow. Figure 2 illustrates a typical example of the southeastern populations. I also examined Brisson's illustration and it, too, is clearly an example of that population. Because Gmelin's (1789) references were based on the brighter bird, Oberholser (1974) erred in stating that they refer to the dark northern subspecies. The correct name for the bright southern populations is *aestiva* and the name for the darker northern populations is *amnicola*.

Gmelin gave two localities in his description of *Motacilla aestiva*: "Habitat Gujana, aestate in Canada." Pennant (1784-85) had stated that the species is found in "Canada where it does not breed" but that it is found in New York and "even Hudson Bay." During the 18th century the term Hudson Bay designated the entire watershed (about 3.6 million km^2) of the bay (Rich 1967). Pennant added that the form, which he called "Yellow-Poll," retires to South America, citing Buffon. Latham (1783) stated that the bird breeds in "Guina," is "found" in America and "seen" in Canada.

The locality "Gujana" appeared in Gmelin more than once and was also spelled "Guganae." These names no doubt refer to Guiana or Guyane (also spelled Guayana), an early name that included the coastal plain between the Orinoco and Amazon rivers (Osborne and Beissinger 1979).

Berlepsch and Hartert (1902) were the first to consider Canada as the type locality of *aestiva*. The locality "Canada" would at first seem vague, but in the historical context of the French colonization in North America "Canada" in the 18th century would have meant the southern part of southeastern Canada along the St. Lawrence River. This area known as New France, included three centers of activity: Québec City, and westward or upstream on the St. Lawrence river, Trois Rivières, and Montréal.

Any of four collections in France may have been the repository of the specimen(s) that were the basis for Daubenton's Plate 58, Figure 2. Brisson is known to have had access to the collections of Abbe Aubry (rector of Saint-Louis), the collection of the physician Mauduyt de la Varenne, the collection of Rene Antoine Ferchault Réaumur, and briefly, the Cabinet de Histoire Naturelle du Roi (Stresemann 1975). There is no information that specimens of *aestiva* ever reached the first two collections but there is evidence that specimens collected in New France may have been deposited in the Réaumur collection.

Two physician naturalists, Michel Sarrazin (Rouseau 1969) and Jean-François Gaultier (Boivan 1974) sent specimens to Réaumur. Sarrazin was known to have lived in Montréal and Québec City. Gaultier received specimens from various forts in New France, the forts all being upstream or west of Québec City. Both physicians regularly shipped specimens from Québec City to Réaumur (Boivan 1974) but there are no records indicating what was sent. Kalm (1937), a botanist from Sweden, met Sarrazin and traveled with Gaultier in 1749-1750. Although Kalm recorded numerous species of birds, he made no mention of any warblers. All three people visited Montréal, Trois Rivières, and Québec City.

Buffon was appointed curator of the Cabinet du Roi sometime before 1744, and Brisson was appointed the curator of the Réaumur collection in 1749 (Taton 1970). The Cabinet du Roi absorbed the Réaumur collection in 1757, and by 1760 Buffon, who was in charge of the newly organized collection, denied Brisson access to the specimens (Taton 1970). This combined collection, which later came to be part of the Paris Museum of Natural History (Stresemann 1975), may have been smaller than the earliest inventory of 463 specimens of birds in 1793 (Farber 1980).

In 1744 Daubenton joined Buffon, and in 1765 he began what he originally called his *Miscellanea* (Cowan 1967). The earlier plates, including Plate 58, were completed by 1767 and issued as Daubenton's *Planches Enluminees* (Cowan 1968). Therefore, specimens available for Daubenton's Plate 58 would likely have been either from the original Réaumur collection or from the Cabinet du Roi before 1757, and were most likely collected somewhere along the St. Lawrence River between Québec City and Montréal.

Several forms of birds based on Brisson's work had the original locality of "Canada" (see McAtee 1957). Oberholser (1914), in discussing two of the forms, *Perisoreus canadensis* and *Pinicola enucleator*, assumed "Canada" to mean Québec City. When *D. petechia amnicola* was recognized (*see* Oberholser 1938; A.O.U. 1944), Todd (1947) followed Oberholser's (1914) assumption and restricted the type locality of *aestiva* to "Québec City." Todd (1947) found that seven of nine specimens of *D. petechia* from Québec City were referrable to *aestiva* and two represented the darker form *amnicola*. The fact that Québec, Québec, is "border-line" (Todd 1947: 326) relative to the geographic distribution of *aestiva* has no bearing because Daubenton's Plate 58, Figure 2, clearly illustrates an example of the more southern birds.

The A.O.U. (1957) accepted Oberholser's (1914) reasoning, and restricted the type localities for the names that Linnaeus and Gmelin proposed based on Brisson variously as "City of Québec," "Québec City," and "Québec City, Québec" except for *Perisoreus canadensis* which was simply given as "Quebec." As three subspecies of that species are listed (A.O.U. 1957) as occurring in the province of Québec, no doubt the intended meaning was the city of Québec, consistent with the other descriptions. To avoid confusion, I recommend that the locality be given consistently as "Québec, Québec."

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Predation on a Ringed Seal, *Phoca hispida*, Pup by a Red Fox, *Vulpes vulpes*

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Andriashek, D., and C. Spencer. 1989. Predation on a Ringed Seal, *Phoca hispida*, pup by a Red Fox, *Vulpes vulpes*. Canadian Field–Naturalist 103(4): 600.

A Red Fox (*Vulpes vulpes*) was observed feeding upon a newborn Ringed Seal pup (*Phoca hispida*) on the sea ice of the eastern Beaufort Sea. Although Arctic Foxes (*Alopex lagopus*) are effective predators of Ringed Seal pups, this is the first known incidence of predation by a Red Fox on the sea ice.

Key Words: Red Fox, *Vulpes vulpes,* predation, Ringed Seal pup, *Phoca hispida*, sea ice.

Arctic Foxes (*Alopex lagopus*) are well known for scavenging on the carcasses of Ringed Seals (*Phoca hispida*) killed by Polar Bears (*Ursus maritimus*) (Stirling and Smith 1975), and as predators of newborn Ringed Seal pups in subnivean lairs (Smith 1976). In contrast, there is only one published record of Red Foxes (*Vulpes vulpes*) scavenging on seal carcasses on the sea ice (Andriashek et al. 1985), although the Red Fox is commonly found along the mainland coast throughout most arctic areas (Voight 1987).

In over 100 000 km of Polar Bear Surveys conducted by the Canadian Wildlife Service in the eastern Beaufort Sea since 1971, this is the only Red Fox that we observed on the sea ice.

On 18 April 1987 we saw a dark phase Red Fox feeding on a freshly killed newborn (approximately two weeks old), male Ringed Seal pup about 76 km northwest of Tuktoyaktuk, Northwest Territories (69° 48′N, 134° 45′W), in the eastern Beaufort Sea. The head of the pup had been eaten and the body was still warm. The body had been dragged approximately 25 m from an external opening at the top of a subnivean lair, which was located on a well-drifted, one meter high, pressure ridge in stable flat ice. Since no other tracks were visible around the carcass we concluded the seal pup had been killed by the fox.

The Red Fox is a direct competitor of the Arctic Fox in areas where both species occur (Hersteinsson and Macdonald 1982), and under controlled conditions it dominates limited resources such as den sites and food (Rudzinski et al. 1982). Macdonald (1987) proposed that the northern distribution of the Red Fox is limited by food abundance, while the southern limit of the Arctic Fox is determined by the Red Fox. Although seal carrion and Ringed Seal pups are readily available near shore, especially in the spring, it is clear that Red Foxes rarely exploit this resource. The reasons for this are not clear.

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Range Extension of *Brachyphallus crenatus* (Trematoda: Hemiuridae) to the Southern Beaufort Sea

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Korczynski, R. E. 1989. Range extension of *Brachyphallus crenatus* (Trematoda: Hemiuridae) to the southern Beaufort Sea. Canadian Field-Naturalist 103(4): 601-602.

Brachyphallus crenatus was found in either one of the paired trunk coelomic spaces of the chaetognath *Sagitta elegans* from the southern Beaufort Sea. The prevalence and intensity of infection was low. This finding constitutes a range extension for *B. crenatus* and the first record for this trematode parasitizing *S. elegans* in Canadian arctic waters.

Key Words: *Brachyphallus crenatus*, trematode, *Sagitta elegans*, chaetognath, Beaufort Sea, range extension.

Extensive plankton surveys conducted in July-August 1987 in the southern Beaufort Sea (69° N, 136° W to 70° N, 127° W), including Tuktoyaktuk Harbour (69° N, 132° W), Northwest Territories, recovered large numbers (n = 3473) of chaetognaths. The chaetognaths (*Sagitta elegans*) were found to be parasitized with the digenetic trematode *Brachyphallus crenatus*.

This finding constitutes a range extension for *B. crenatus* to the southern Beaufort Sea and the first record of a digenetic trematode parasitizing this chaetognath species in Canadian arctic waters.

Brachyphallus crenatus is a widely distributed and common fish trematode occurring primarily in the alimentary tract of salmonids. The nearest known reported distribution for *B. crenatus* is British Columbia (Bangham and Adams 1954); it has also been reported from Washington (Lloyd 1938) and Oregon (Shaw 1947). In eastern Canada, it has been reported from the Labrador-Newfoundland area (Bourgeois and Ni 1984). Other reported areas include Japan (Yamaguti 1934), Britain and the North and Baltic Seas (Dawes 1968).

The intensity of infection observed was one adult trematode clearly visible on external examination in either one of the paired trunk coelomic spaces of the chaetognath; the exception was one which occurred within the intestinal tract. The morphometric range, based on preserved material, for the adult trematodes obtained was 0.68 — 1.36 mm ($\bar{x}$ length = 1.02). Odhner (1905) recorded variations of 0.8 — 2.5 mm for *B. crenatus*, Dawes (1968) from 3.2 — 3.6 mm, Linton (1927) from 1.02 — 1.08 mm, and Lloyd (1938) at 3.0 mm. Twenty-two ($< 1\%$) of the chaetognaths ranging from 21.5 — 34.0 mm in total body length were found to be parasitized. It is not believed that *B. crenatus* causes damage to the chaetognath as there was no evidence of tissue or muscle degeneration and ovaries remained intact. The low prevalence of infection reported may be a combination of a reduced number of parasites actually seeking hosts and a high density of susceptible hosts available.

Sagitta elegans has been reported parasitized by digenetic trematodes. Linton (1927) reported one specimen of *S. elegans* from Woods Hole, Massachusetts, parasitized by two adult digenetic trematodes, tentatively identified as *Distoma ocreatum* or *Hemiurus ocrenatus*. Both species reported are now accepted as synonyms of *B. crenatus* (Dawes 1968). Myers (1956) examined six trematodes from several specimens of *S. elegans* collected at St. Andrews, New Brunswick, and tentatively identified them as *Hemiurus levinseni* but did suggest that there was a resemblance to those described by Linton (1927). Kulachkova (1972), however, did report *B. crenatus* parasitizing *S. elegans* in the White Sea and observed a high prevalence in September-October.

There is a paucity of information on the effects of parasites on chaetognaths. Infection by larval trematode parasites has caused gigantism in chaetognaths and lowered reproductive potential (Pearre 1976) and increased susceptibility to predation (Pearre 1979).

The morphology of the trematode is detailed by Lander (1904) and Lloyd (1938). The life history of *B. crenatus* is hitherto unknown (Pratt and McCauley 1961; Kabata et al. 1988). Specimens have been deposited in the invertebrate collections of the Department of Fisheries and Oceans, Winnipeg, and Invertebrate Research Associates, Winnipeg.

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News and Comment

1988 Ottawa Field-Naturalists' Club Awards

Based on nominations received in late 1988 and on Awards Committee recommendations, the Council of The Ottawa Field-Naturalists' Club approved granting of awards as described in the following sections.

For the first time in 10 years no Honorary Members have been selected. This is because Council operates according to a motion (recorded 9 September 1985) stating that a limit of 25 Honorary Members is to be established, and currently the quota is filled. This limit helps maintain the significance of nomination to Honorary Membership.

Also for the first time since inauguration of the Club's own awards series, a member has been granted two awards at once. This is related to the Alfred Bog project, where Awards Committee, and then Council, agreed that the subject was important enough to justify the double award.

Service Award 1988: Lois Cody

The 1988 OFNC Service Award is given with particular pleasure to Lois Cody.

Lois first started working for the Club in 1968, as bookkeeper for *The Canadian Field-Naturalist.* Since then, with the exception of the years 1975 to 1978, she has put in many hours keeping track of the Journal's finances, and since 1979, the Club's as well.

Lois also handles the incoming mail, sorting it and directing it to appropriate officers and Committees, with copies when useful. Incoming money is recorded and banked. Since several different Committee budgets may be involved, this latter task is not always simple. Subscriptions and other payments to *The Canadian Field-Naturalist* must be kept separate from Club dollars. Donations to the Club and to its special projects such as Alfred Bog must be separately assigned and receipts provided. Finally, mail orders for publications and other items are processed.

Lois rounds out her support of the Club with her cheerful presence at social occasions. She is also active in many other fields, such as golfing and curling, and as a Friend of the National Gallery, although she has given up her involvement with the Girl Guides. It seems that for Lois, service is a way of life.

Member of the Year and Conservation Awards: Frank Pope

For the first time since the establishment of The Ottawa Field-Naturalists' Club awards, one individual has been granted two awards in one year. This distinction was achieved last year by Frank Pope — our joint Member of the Year and Conservation Award winner.

Frank has had an important career in the Club including sitting for 10 years (so far) in Council, serving on several Committees, acting as Chairman of Finance Committee, and as President in 1984 and 1985. These activities would normally be enough for award consideration, but Frank saw a cause and he championed it — a cause very central to what our Club is all about. He took over in 1985 as chairman of a steering group, representing many conservation organizations, established to save Alfred Bog. This well-known and nationally significant bog east of Ottawa was slated for agricultural development.

Frank Pope was the catalyst for the intensive activities that resulted last year in an agreement to purchase 1500 hectares of the bog for nature conservation. He never gave up hope that the purchase would go through, and he continues now to spearhead efforts of the Club to raise more funds for land purchase, and to develop appropriate management procedures.

Not content with this heavy schedule, Frank has continued his role on Council and as Finance Chairman, and then filled the temporarily vacated treasurer's position for half the year. Always ready to step in where needed, Frank Pope is a worthy recipient of these two awards.

Anne Hanes Natural History Award: Daniel F. Brunton

Dan Brunton is prominent in our Club, having served as President and in many other offices. He has provided us with numerous articles on district flora and fauna and their habitats, in *Trail & Landscape* and *The Canadian Field-Naturalist*. He is particularly well-informed on the history of the Club. His recently published book, *Nature and Natural Areas in Canada's Capital*, singled out from his other accomplishments, makes him a worthy recipient of the Anne Hanes Natural History Award, with its emphasis on natural history in the Ottawa Valley.

This book was published by *The Ottawa Citizen* in co-operation with the Club. Its purpose is to provide ready information concerning the natural history of our area.

With his extensive knowledge of this area, Dan has produced a comprehensive field guide that will be used by visitors and residents alike for many years to come. It makes even those of us who have long lived here more aware of the wealth of flora and fauna, and the beauty spots available to us. Thirty different "Places to see" are covered.

Dan's book, already well received by the public, will add to the stature of the Club.

BILL GUMMER,
Chairman and Awards Committee Members
The Ottawa Field–Naturalists' Club

1988 President's Prize: Marg Benson

The fourth of the modern President's Prizes was presented to Marg Benson. It recognizes her work in arranging the Club's participation in the 1988 Peregrine Falcon release program. This included learning what the Canadian Wildlife Service and the Ontario Ministry of Natural Resources hoped to accomplish, devising a plan to fit, arranging for volunteers to observe and keep records of young birds' behaviour and actions during the critical first weeks following release, and being prepared for an alert if anything went wrong. She ensured that teams and leaders recognized program requirements.

Our Club thrives on volunteer efforts, and Marg has used her personal skills and interests in this program. She succeeded in involving more volunteers from the general membership than previously done, with a total of nearly fifty people.

Past President Bill Gummer thanked and congratulated Marg for her interest and for showing that the Club could be of real use, and presented her with the 1988 President's Prize; her selection was *Stein — The way of the River*.

BILL GUMMER
Past President,
The Ottawa Field-Naturalists' Club

Northern Science Award 1989: William O. Pruitt, Jr.

Indian and Northern Affairs Canada. 1989. Northern Science Award 1989: William O. Pruitt, Jr. Canadian Field-Naturalist 103(4): 605-606.

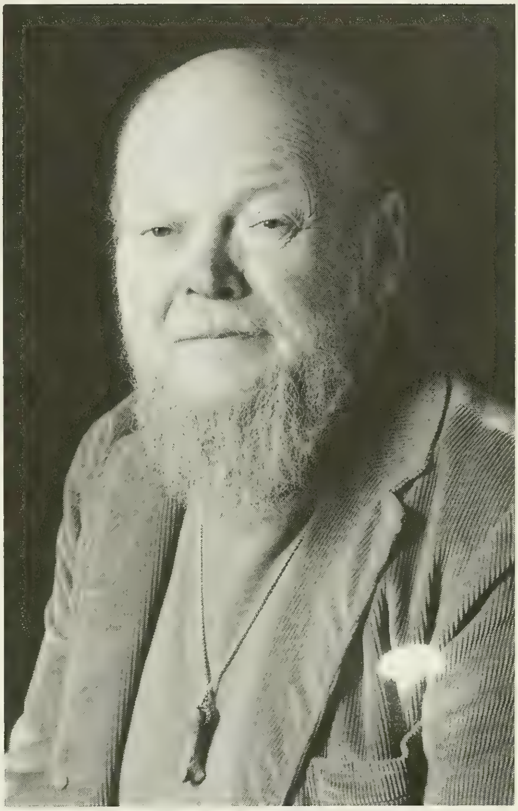
Dr. William O. Pruitt Jr., Professor of Zoology from the University of Manitoba, was the 1989 recipient of the Northern Science Award. Pierre H. Cadieux, Minister of Indian Affairs and Northern Development, made the presentation in a ceremony in the auditorium at the Lester B. Pearson Building, Ottawa, the evening of 9 November 1989.

The Northern Science Award is presented annually to an individual who, through his or her work in the sciences (including the social sciences and humanities), has made a significant contribution to knowledge and understanding of the Canadian North. This year's ceremony honouring Dr. Pruitt marked the sixth anniversary of the Award, which consists of a Centenary Medal and a $5000 cash prize.

Minister Cadieux noted that, in addition to earning scholarly acclaim, "Dr. Pruitt has instilled in many of his students a love and respect for the land and animals of the North."

A five-member selection committee, this year chaired by Dr. T. H. B. Symons of Trent University and including Dr. Bernard Arcand, Ann Hanson, and Dr. Peter Adams, chose Dr. Pruitt for his contributions and experience relevant to achievements in northern science. The committee is composed of northerners as well as representatives from professions involved in expanding basic understanding of northern science.

The Northern Science Award and Centenary Medal was established in 1983 to mark the hundredth anniversary of the International Polar Year (1882-1883). Between 1 August 1882, and 1 September 1883, the first world-wide coordinated scientific enterprise took place when 11 countries established 12 stations in the Arctic and two in the Antarctic and carried out simultaneous observations in the earth sciences.



William O. Pruitt, Jr. Photograph by Jim Stodnick, 1989. Courtesy Indian and Northern Affairs Canada.

This award, an acknowledgement of achievement, also seeks to encourage research, understanding and development for the future of Canada's North.

William O. Pruitt, Jr. is a Professor of Zoology at the University of Manitoba in Winnipeg. Referred to as "the snowman" by his colleagues and students, Dr. Pruitt is also called the Father of North American Boreal Ecology and has spent much of his life actively studying one of Canada's most plentiful natural resources — snow.

Dr. Pruitt received his doctorate from the University of Michigan in 1952, after which he involved himself in research and teaching in Alaska. After moving to Canada in 1965, Dr. Pruitt taught at Memorial University of Newfoundland for four years before accepting a position with the University of Manitoba in 1969.

Since arriving in Winnipeg, Dr. Pruitt has fostered and developed a growing interest in boreal ecology — particularly as it pertains to snow. This includes the study of the subnivean qualities of snow (its insulating properties and carbon dioxide levels) and the study of mammals which inhabit an environment covered in snow.

In 1973, Dr. Pruitt founded the University of Manitoba Taiga Biological Station, located in the boreal forests of Atikaki Provincial Park about 240 kilometres northeast of Winnipeg. Still in charge of the station, Dr. Pruitt not only encourages his students to visit but also makes it a requisite for the courses he teaches in Mammalogy and Boreal Ecology.

In Canada, snow research has not been granted the same priority that it has in other northern climes. Dr. Pruitt does not view this lack of interest as a detriment. Instead he espouses, "Canada is unique. We still have a wilderness and the opportunity to study what a complete ecosystem can do."

In addition to his work at the University of Manitoba, Dr. Pruitt has published extensively in both scientific journals and popular publications. He is also part of a network of circumpolar scientists, including Scandinavians and Soviets who regularly exchange research findings.

Source: Information sheets: Indian and Northern Affairs Canada, 9 November 1989.

Editors note: Dr. Pruitt has also served as an Associate Editor of *The Canadian Field-Naturalist* 1971-1976, 1979 to the present.

Address at the Northern Science Award Presentation, 9 November 1989

WILLIAM O. PRUITT, JR., Department of Zoology, University of Manitoba, Winnipeg, Manitoba R3T 2N2

Pruitt, William O., Jr. 1989. Address at the Northern Science Award Presentation, 9 November 1989. Canadian Field–Naturalist 103(4): 606–609.

Mr. Minister, Ladies and Gentlemen:

Erna and I moved north in 1953. Since then I have studied northern mammals and their adaptation to northern environments in Alaska, Northwest Territories, Saskatchewan, Manitoba, Newfoundland, Sweden, Finland and USSR. We have experienced wildly fluctuating levels of financial and intellectual support. Erna has kept the whole operation from falling apart.

I believe the high point of governmental support for northern scientific research was in 1970-1973 with the International Biological Programme. Since then I have seen a progressive withdrawal of the Federal Government from support of northern science. What is clearly a Federal responsibility (and what in every other northern country is recognized as a responsibility of the central government) has, in Canada, been sloughed off and turned over to unwilling provincial and immature territorial governments and, most unfortunately, to transnational corporations. These corporations have been delighted at their sudden, unexpected ability to direct and control northern research to their own benefit.

In times before the Government's abrogation of responsibility, scientists had protection from outside exploitive and commercial interests because they were Federal civil servants or university faculty; they also had stability of careers. With the abrogation of responsibility by the Federal Government, the actual northern scientific research shifted to small, sometimes ephemeral, consulting companies who were, themselves, beholden to the transnational exploitive corporations that hired them. Thus began the starvation of northern biological research that continues today.

Northern field biology is particularly susceptible to control by the transnational corporations by way of these consulting companies. I certainly do not mean anything as gross as false reports or false data but in the wrong questions being asked. I do mean, however, that there are subtle (and not so subtle) pressures to produce environmental recommendations that are not out of line with a prevailing climate of opinion. Scientists lacking long-time familiarity and commitment to a given region or restricted subject, but assigned the work on a short-term basis, cannot appreciate the niceties or intricacies of a subject or the peculiar environmental sensitivities of a certain region and therefore cannot be expected to ask the correct questions. If the scientists do not, then who will? The answer is: No one.

For example, consider an application for a new mine in a tundra region. Environmental Impact Statements are required, so a consulting company is hired by the mining company. Consulting company scientists are brought in to study effects of access roads, water diversion, tailing ponds, etc. etc. on caribou migrations and other biological phenomena. Long, detailed reports are submitted. But no one has yet asked the critical question: "Is the mining project itself justified?" The only justification is the short-term economic profit-and-loss analysis by the mining company itself. This may be good capitalism but it is damned poor ecology.

I have also noted increasing difficulty of getting NSERC grants for northern field research. The change in the regions of interest to DIAND, restricting them to regions of permafrost, ignores several important facets of the definition of Nordicity such as distribution of animals and plants as well as the human factor of *isolation*. This foolish decision further restricted support for northern research.

As an example, I may mention the severe effect it has had on the northern research at Taiga

Biological Station of the University of Manitoba. With DIAND support we had a planned programme of long-term research. This stability of research support disappeared and we now exist from year to year by grace of a private research trust and small grants (on the order of 1 to 3 thousand dollars) from the Province, Canadian Shield Foundation, World Wildlife Fund, various wildlife clubs, Manitoba Naturalists Society and small private donations. The whole situation is unhealthy for northern science. That is why the 5 thousand dollar prize accompanying this award is so valuable and appreciated — it means I can support a student in the field for almost a year.

Of course, with the shift in Federal Government goals from maintaining an independent northern nation to changing it into a fragmented and incidentally northern warehouse of resources and cheap labour for benefit of the dying nation to our south, this is probably all part of a grand governmental plan. Let us pray that this plan is soon frustrated.

Because the Brundtland Report, the Federal Task Force on Economy and the Environment as well as the Free Trade Agreement (FTA) all involve impacts on northern environments, I would like to discuss these policies and laws. Neither Brundtland nor the Federal Task Force takes into account any serious consideration of the major climatic change looming in the immediate future, although there is now a large body of empirical data and many extrapolations of the effects this enhanced "greenhouse effect" will have on northern Canada and particularly Manitoba. A recent analysis describes some studies that calculate northward shifts of the southern boundary of the taiga or coniferous boreal forest from 250 to as many as 950 km, with its replacement by northern hardwoods forest, aspen parkland or even grassland vegetation. In addition, there is mounting evidence that a more valuable use of the boreal forest (taiga) will be simply to remain growing, as a carbon sink.

The Manitoba Task Force on the Environment has, therefore, recommended that the Provincial Government do all in its power to persuade the Federal Government to install (or re-install) programmes and financial support to reduce drastically Canadian burning of fossil fuels by means of, for example: (1) encouraging and subsidizing train travel instead of subsidizing aircraft, bus or automobile travel; (2) by electrifying the transcontinental line of Canadian National Railways; (3) by preferential use of such an energy-efficient mode of transportation as steel wheels powered by hydroelectricity and running on steel rails, for government travel and shipping, including some categories of Canada Post, instead of air, bus, truck or automobile travel and shipping; (4) by elimination of direct or indirect support of any project intended to explore for, or increase extraction, consumption or export of petroleum or other fossil fuels.

One major thrust of the Free Trade Agreement is to *increase use* of fossil fuels (Articles 409, 904a, 906), in spite of the conclusions of the International Conference convened in Toronto in 1988 by the Federal Department of the Environment (!) that a *50% decrease* is necessary. The Government itself sponsored this conference and gave much lip service to its conclusions but has acted just the opposite.

The United States now uses about 986×10^6 m^3/yr of oil and produces about 115×10^{12} gm C/yr, or 25% of the world's total atmospheric burden of carbon. Canada already exports to the U.S. about 30% of its yearly oil production and about 38% of its natural gas production. Canadian oil sold to the U.S. thus, alone, contributes about 4% of the atmospheric carbon given off by the U.S. The recent disastrous decision by the National Energy Board to allow *additional* export of 1.28×10^{10} m^3/yr of natural gas to the U.S. means that our contribution to the U.S. release of "greenhouse gasses" will be *increased* by approximately 1 percent. Articles 409 and 904a of the Free Trade Agreement force Canada to furnish the U.S. the same proportion of the total supply of Canadian gas, oil, water, etc. as it did in the previous 36-month period. Canada cannot reduce the proportion of total energy exported to the U.S. below the proportion exported in the previous 36-month period, no matter how much we want to reduce pollution by greenhouse gasses. This locks us into a spiral of ever-increasing exploitation of oil and natural gas (and therefore *increasing* our contribution to the world-wide "greenhouse effect.") instead of a *decreasing* spiral resulting from conservation of energy and reduction of use of fossil fuels. This is also just the opposite of the recommendations of the Brundtland Commission Report.

The Free Trade Agreement is designed to *decrease* activities in energy conservation, alternate non-fossil sources of energy and soft energy paths (Article 506). It violates the spirit of the Brundtland Report as well as the recommendations of the government's own Task Force on Environment and Economy. The recent devastating cutbacks in the budget of the Department of Energy, Mines and Resources and the National Research Council in the fields of research on non-fossil fuel sources, energy conservation and soft energy paths indicate the government is following the dictates of the Free Trade Agreement. Therefore, the Manitoba Task Force on Environment has recommended the Provincial Government do all in its power to persuade the Federal Government to rescind the Free Trade Agreement with the USA.

The present Federal Government has the worst record on environmental matters of any Government in the history of Canada (e.g. — savaging of the Department of the Environment and Canadian Wildlife Service, loss of nearly half the employees of the Department of the Environment, slash of over 50 million dollars from its budget, selective stopping of research on pollution caused by supporters of the Government, dramatic cuts to the budget of the Department of Energy, Mines and Resources and the National Research Council, etc.). Therefore, the Manitoba Task Force on Environment has recommended that the Provincial Government do all in its power to persuade the Federal Government to restore the activities of the Department of the Environment, Canadian Wildlife Service, the Department of Energy, Mines and Resources, and the National Research Council especially in the fields of pollution research, soft energy paths, alternate energy sources and energy conservation.

The Brundtland Report and the Federal Task Force on the Environment and Economy are both flawed because of minimal scientific input. Because of its unfortunate choice of English words, the Brundtland Report has been gleefully interpreted by exploiters and some politicians as advocating "sustaining the present level of development." The Federal Task Force (and the resulting "Round Tables") are heavy with industrial people who cannot solve the problems because *they are* the problem! Would you trust the president of INCO to write air pollution regulations? Would you trust the president of MacMillan-Bloedel to write regulations governing sustainable multiple use of our forests? Would you trust the president of Union Carbide to write safety regulations for a factory to manufacture pesticides?

The world-famous Canadian ecologist Dr. Stan Rowe recently wrote: "The order of the words in the United Nations-sponsored 'World Commission on *Environment and Development'* wisely implied that environment precedes development and is the latter's prerequisite. No environment, no development. Nevertheless, somewhere along the line when the Brundtland Report, *Our Common Future*, was being written this bit of wisdom got lost. Instead, the Commission adopted Sustainable Development as its centrepiece, and in its follow-up the Canadian Task Force — mindful that commerce rules the world — further refined the goal toward which all should strive as *Sustainable Economic Development*. Whatever happened to *Sustainable Environment?*"

Neither report takes into account human populations having equitable access to the sustainable resources of the world; without reduced, stable human populations all environmental "solutions" become irrelevant. Nearly 20 years ago Bill Fuller expressed the situation best: "The plain facts are that we are unable to support the number of people we now have — either globally, where two billion people go to bed hungry or starving every night, or in Canada, where 30% to 40% admittedly live at, or below, an arbitrarily defined poverty level, or in the North where some of the greatest economic poverty in Canada exists. Yet those who follow the conventional wisdom here, or in India, or in any other country, or in the U.N., have yet to make a forthright statement on the need to *reduce* the human population of this country or this planet. This is a far different thing from advocating family planning to slow the rate of increase. Family planning, unless rigorously pursued to bring about a decrease in population, is merely an exercise in a vacuum. Barring catastrophe, human numbers will reach about 7 billion by the year 2000 and could attain 56 billion by 2100. This is greater than the population that even one of the most outspoken critics of human population control believes the earth is capable of supporting."

Both Brundtland and the Federal Task Force on Economy and Environment are based inherently on laissez-faire market capitalism, not on ecology. They talk about an era of "unparalleled economic growth" but their acclaim forgets that "unparalleled economic growth" is the motto of the cancer cell. The "partnership" between private and public sectors that these reports extol cannot solve the environmental problem. Indeed, such an incestuous relationship is precisely what is producing the looming environmental collapse. If the sole aim of a society is to help companies manufacture widgets at the most efficient rate, regardless of whether widgets are needed or not, or whether they are environmentally damaging or not, then the conclusions of Brundtland and the Federal Task Force are valid. If, however, the aim of a society is ecosystem stability (as ecology tells us it must be), then we must reject these outdated theories of flat-earth economics. We, collectively, must first decide if widgets are environmentally safe, are necessary, and, if so, how many shall we make in order to satisfy society's needs? Therefore, we must plan all aspects from mining or growing the material, to manufacturing or processing, to distribution, to use, to final dissolution so that recycling and environmentally-safe processes occur at all steps. In other words, the Brundtland Report makes nice-sounding, quotable phrases, but the crucial methods advocated for solving the problem turn out to be more of the same old stuff.

Mr. Minister, I urge you and your colleagues to rethink your role and position in the biosphere, to forget your dearly-held ideals of laissez-faire market economics and continual economic growth, to begin to think ecologically and to act positively on changes such as those proposed in the recommendations I have described.

I shall leave you with a paragraph I wrote long ago in *Wild Harmony*: ". . . In regions of reduced energy input, slow vegetational succession and low mammalian biomass, all human schemes must be examined critically from an ecological perspective. The decision to implement any scheme must come only after we know it will not degrade the ecosystem. The ecological history of the white man's invasion of boreal regions teaches us one unassailable fact: any obligatory restriction to profit-oriented free enterprise as the sole economic system allowed is incompatible with ecosystem stability. Under this system no scheme or action dare be undertaken unless a profit is predicted, and, conversely, any scheme or action that promises a short-term profit is automatically considered desirable. The boreal regions are too important to the future of mankind to allow their use to be governed by only one preconceived economic system. The only valid criteria for determining use are ecological ones."

I am grateful to the Selection Committee for the singular honour they have bestowed upon me. I accept the honour on behalf of my students and colleagues who, in spite of increasing difficulties and decreasing support, have contributed, and continue to contribute, so much to our knowledge of northern ecosystems and their mammals. And I accept the five thousand dollar prize on behalf of Taiga Biological Station and the student that the money will, one day, support.

A Tribute to IBRA L. CONNERS, 1894-1989

D. B. O. SAVILE

Biosystematics Research Centre, Agriculture Canada, Research Branch, Central Experimental Farm, Ottawa, Ontario K1A 0C6

Savile, D. B. O. 1989. A tribute to Ibra L. Conners, 1894-1989. Canadian Field-Naturalist 103(4): 610-612.

Ibra Lockwood Conners was born on 5 July 1894 at Rodney, Elgin County, Ontario. He died at Lafayette, Indiana, on 12 May 1989. He received his B.A. from McMaster University in 1918. As an undergraduate he worked out of St. Catharines, Ontario, on the white pine blister rust survey. He earned his M.A. under J. H. Faull from Toronto in 1920. He then joined the Division of Botany and was posted to Brandon, Manitoba, by Dr. Güssow, to work on control of cereal smuts. He worked at Brandon until 1925, but spent one winter on graduate study at the University of Minnesota, and one at Saskatoon where he studied the rusts of the prairie provinces with W. P. Fraser. From Fraser he learnt the meticulous study methods demanded by these fungi, which stood him in good stead in later years. In 1925 he was transferred to Winnipeg, to study control of cereal smuts at the new rust research laboratory. In 1929 Dr. Güssow brought him to Ottawa specifically to take charge of the annual plant disease survey reports and the mycological herbarium. With his field and herbarium experience under W. P. Fraser, in addition to his academic training, Conners was well fitted to be curator of the herbarium. He promptly visited several major mycological herbaria in the United States. He thus avoided the dangerous mistakes often seen in small herbaria, and organized the herbarium with a system that was flexible enough to allow later expansion with little difficulty, for which his successors have been grateful.

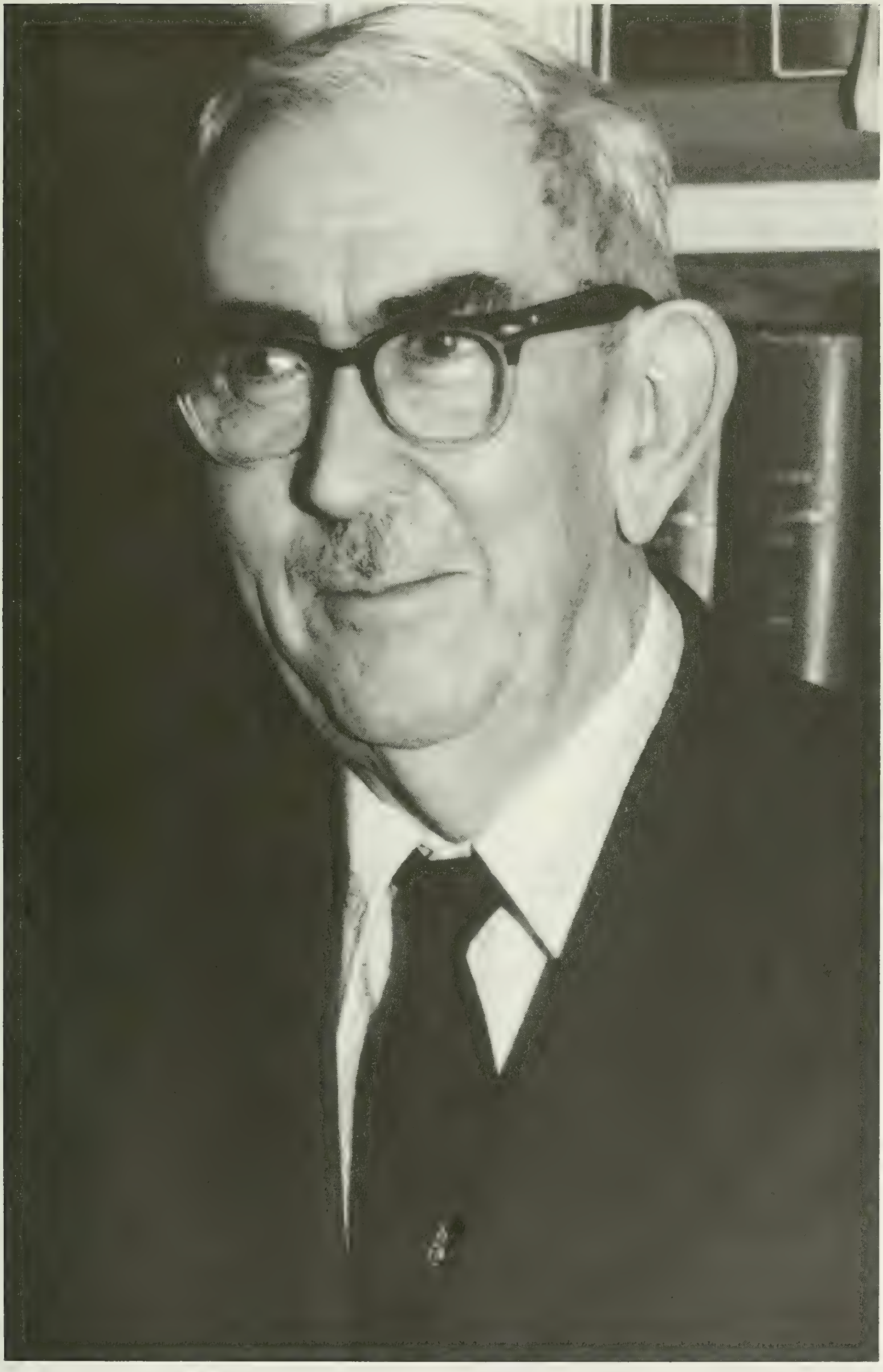
The Canadian Plant Disease Survey had been operating, somewhat erratically, for nine years under several compilers. Mr. Conners quickly standardized the procedure for gathering data; and thenceforward the annual reports appeared with great regularity except for occasional delays in mimeographing. In all, he issued the reports for 28 years, 15 alone and 13 with co-compilers. Under him the Plant Disease Survey attained an enviable international reputation, largely because he would not accept a dubious report unless backed by a satisfactory specimen. In this way the survey also strengthened the mycological herbarium.

As curator of the mycological herbarium, alone or with one assistant, Ibra was for many years an identification service, to whom were directed not only fungal specimens, but mite or insect damage, physiological disorders and even cyanobacteria and algae. In 1943, an army officer, worried about fungal damage to optical equipment, was brought up to us; and we were immediately plunged into a new war-born science called tropic-proofing, which finally led to redesigning optical instruments.

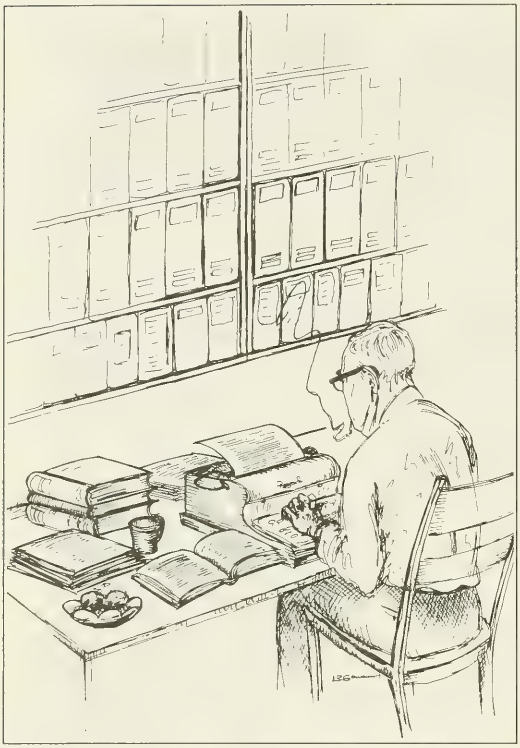
At a moment of frustration in 1950 he proposed the formation of a mycology section in the division, with J. W. Groves in charge. With active support from Harold Senn (remembered by club members as editor of *The Canadian Field-Naturalist*) the proposal went through promptly; and in 1951 we became mycologists in name as well as in fact.

Starting in 1939, Ibra Conners was in charge of the registration of fungicides based on their biological effectiveness, which he did until 1962, two years after he reached retirement age. He had received a two-year extension specifically to let him finish a book, but the replacement, who worked only on fungicide registration, was not appointed until the extension period was over. People occasionally remarked that Ibra published few research papers. However, numerous research notes were included in the survey reports. Any doubting Thomas should look at the 45 cm of shelf space occupied by his 28 reports; and to him I would, unoriginally, say "Si monumentum requiris, circumspice!" And why did Conners ask for that extension? Yes, to finish a book, and despite the road blocks, and with the editorial help of Don Creelman, he did soon finish it; but, with printing delays, it did not appear until 1967: *An Annotated Index of Plant Diseases in Canada and Fungi Recorded on Plants in Alaska, Canada and Greenland*; one of the most valuable works in its field ever published.

At almost age 73, when the book appeared, did Ibra finally quit? No, indeed, he was already working full time on a daunting project: to assemble the original descriptions and illustrations, in photocopy, of all the genera of



A photograph of Ibra L. Conners, taken just before his 80th birthday by M. P. Corlett, showing him in spry middle age.



Sketch by Linda Gowans, made at about the same time as the photograph, shows Mr. Conners at work in typical pose. Dammit, we always said he would die young if he kept smoking.

fungi and their type species — a job that will not end as long as new genera continue to be described. Feeling, no doubt, that he had not enough to keep him busy, the Canadian Phytopathological Society urged him to gather first hand accounts of the growth of plant pathology in Canada. Ibra, a long-standing C.P.S. member and president in 1937-38, travelled coast to coast in this endeavour and produced *Plant Pathology in Canada* (1972). Credited by the editorial committee with being its editor, he did in fact write or re-write most of it; and, in defence of such a meticulous author, I must point out that nearly all the errors in the text were inserted by the committee. A full list of his publications will be published in *Mycologia*.

Ibra worked steadily at his open-ended project on the genera of fungi until 1977; then, feeling the strain of keeping house for himself, he moved to West Lafayette, Indiana, where his daughter, Helen Crane, lives. There, for several years, until his health began to fail, he helped Dr. J. H. Hennen in the Arthur Herbarium at Purdue University.

Surely nobody could expect a man with two or three official jobs to have any serious outside interests. Well, it did not quite work out that way. Ibra joined The Ottawa Field-Naturalists' Club in 1933. He was club treasurer from 1943 to 1946, he was on council from 1943 to 1960, and he was an auditor from 1949 to 1961. He was also largely repsonsible for arranging for the club to sponsor the Audubon Screen Tours, which gave the club a substantial equity.

In 1979, the Canadian Botanical Association awarded Ibra Conners the Lawson Medal in recognition of his contributions to Canadian botany. In 1987, the Ottawa Field-Naturalists' Club made him an Honorary Member. The genus *Connersia* was named in his honour by Dave Malloch in 1974.

Ibra Conners was married in 1926 to Natalie Louise Thompson, of St. Paul, Minnesota, who died in 1967. He is survived by his daughter, Helen Crane of West Lafayette, Indiana, and a sister, Kathleen Malloch of St. Catharines, Ontario.

Book Reviews

ZOOLOGY

Atlas of the Wintering North American Birds: An Analysis of Christmas Bird Count Data

By Terry Root. 1988. University of Chicago Press, Chicago. 312 pp., illus. Cloth U.S.$60; paper U.S.$35.

Finally someone has put some of the immense mountain of Christmas Bird Count (CBC) data to use. Only ten years worth of this information (1962 to 1972) has been computerized and the author has based his book on this data block. As CBC data have not been collected under a rigorous scientific protocol, the author has had to establish some stringent guidelines for their use. This he explains clearly and points out the imperfections and why they occur. The author has then applied his assessment method to the stored data and presented the results as two types of map. The first is a simple contour line presentation. The second is a fishnet type that is shown as a "three-dimensional" puckering with increased abundance separated by height (like a chequered table cloth laid over a series of different height bottles).

The book is divided into three sections. The first contains those birds which the author feels the data are accurate enough to provide meaningful maps. Both types of map are given for each species. The second section lists all the birds found on the CBCs in the time period covered. The last section has smaller sized contour maps only and these are for data that are somewhat questionable. For each bird mapped there is a commentary giving the author's assessment of the results.

I have a number of problems with this book. Although the title infers it covers North America, it is in fact strongly biased towards the USA. The maps stop at the latitude of northern Vancouver Island and most of Canada, including all of Cape Breton and Newfoundland is not depicted. (This is more a nationalist rather than a scientific sentiment. Most of the wintering ranges are in the U.S.!) More pertinent are the problems I have with the maps. I would have been happier with a single map type for all species (after all, the two maps give the same data in different formats.) The contour map's information is not immediately obvious. The fishnet map is more appealing but valuable information "disappears" behind the abundance peaks needed to maintain the 3-D illusion. The author supplies transparent overlays for temperature, elevation, vegetation, etc. These are difficult against the fishnet background and, of course, the 3-D effect distorts the real distribution. I think a contour style map with increasing intensity of shading to represent the changes in abundance would have been easier to use if less artistic. The author has also used the same base map for all birds. Many of the winter ranges are confined to Florida or California, and detailed maps of these areas would be more informative and useful. The commentary for the maps shown in the third section is given in the first section. This means you have to flip back and forth constantly.

In contrast to my negative comments on the maps, I found the text excellent. It is well written and the ideas presented are carefully researched and provide much food for thought. For example, the author suggests that the Black-billed Magpie's range is limited to areas that do not get too hot but receive less than 24 inches of rain per year. This certainly fits the North American distribution, but how does it explain the European distribution, especially rain-soaked Britain? This is typical of the many interesting questions raised by the text. The most disturbing point I saw in the book was that so many of our summer birds winter in Florida or California. The current pace of development in those two areas means that these wintering zones are at risk. Perhaps we Canadians should pay as much attention to conservation issues in these states as we do to summer breeding areas.

I am happy to recommend this book to all serious birders. The maps, despite their shortcomings, will be useful. The text is so well done it is worth buying the book for this alone. In fact, I think this book should be part of the basic birder's library.

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Hawks in Flight: The Flight Identification of North American Migrant Raptors

By Pete Dunne, David Sibley, and Clay Sutton. 1988. Houghton Mifflin (Canadian distributor, Thomas Allen, Markham, Ontario). 254 pp., illus. $20.95.

This book is, to quote from the flap notes, ". . . the first holistic bird guide". Whether this be true or not, the contents are a boon to those interested in birds of North America in general and, particularly, hawks and hawkwatching. The holistic method differs from the classic identification method, which emphasizes field marks, because as the authors say, it ". . . focuses on the bird as a living organism, with identifications that are based on behaviour, flight style, and relationship to the environment, as well as classic field marks."

As a hawkwatcher of some experience I looked forward to reviewing this book, but at the same time I anticipated that it would have little to offer me. I was wrong. Even veteran hawkwatchers and birdwatchers will find this handy guide an invaluable reference. Despite the authors statement that the guide was not designed to be carried into the field, I for one plan to do so, as the wealth of detail and excellent line drawings deserve to be reviewed frequently in order to sharpen one's identification skills.

Hawks in Flight, which has a thoughtfully prepared Foreword by no greater authority than Roger Tory Peterson, inventor of the original "field marks" system of identification, is carefully designed to treat species with an eye toward shared traits and appearance. Thus, there are separate chapters covering Buteos, Accipiters, Falcons, Kites, the Northern Harrier, Eagles, Vultures, and Ospreys, with a total of 23 diurnal raptors described. The book has, admittedly, an eastern North American bias in terms of the species covered (which the authors willingly acknowledge and hope to correct in future editions), but this does not distract from its usefulness. The 23 species that were selected were chosen because they constitute the medium to long migration raptors or were species which have a tendency to wander.

Each chapter first treats aspects of the migration of each species, then carries on to discuss, in detail, the "holistic" identification of each raptor, and finally concludes by telling the reader how to distinguish raptors with very similar appearance, for example, a Sharp-shinned Hawk and a Cooper's Hawk. Emphasis is placed on the appearance of the hawk at a distance of at least 0.5 km, which is often how migrating raptors are first seen. Every chapter is well illustrated with black-and-white line drawings by David Sibley, 92 in all, again with the emphasis placed on the "feel" of the hawk. These are excellent, if somewhat stiff in presentation. Unfortunately, as a result of the size of the picture used of each bird, normally 1/3 of a page or more, in itself not a bad thing for clarity's sake, it was at times frustrating to have to constantly flip back and forth over the pages in order to fit description to illustration. Perhaps this small inconvenience could be addressed in further editions.

I found the chapter on the identification of accipiters, a subject close to the heart of hawkwatchers (and often a source of frustration for many), very valuable and well explained. I suspect, however, that this will not be the final word in this difficult area. At the end of the book is a collection of 173 black and white photographs by Clay Sutton, many of which were carefully selected to illustrate the appearance of the hawk in situations where normal field marks are either partially or completely lacking — not an easy task. Others emphasize differences between hawks of similar appearance or distinguish immatures from adults or female from male. I am pleased to say that this objective was achieved in the majority of cases despite the darkness, or lack of sharp focus, or both of several of the photographs.

The text is enlivened by the talented and somewhat humerous writing of Pete Dunne. It is obvious that the wording was very carefully considered, yet this is achieved without appearing contrived. My only criticism of the text lies in it being a little too wordy for quick reference. The authors apparently address this problem by adding identification notes to selected drawings of individual species. A summary of all the salient points at the end of each chapter or the entire book would, however, be a most welcome addition to the next edition.

This book is highly recommended and is a must for all students of raptor identification, particularly since no present "Peterson style" field guide contains the wealth of flight identification information contained in this book. It is a fitting companion to the masterly book by Porter et al. entitled *Flight Identification of European Raptors*, which this guide closely mimics and to which it will inevitably be compared. The authors of *Hawks in Flight* should feel proud that their book, presently only in its first edition, comes even close to this classic.

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On Watching Birds

By Lawrence Kilham. 1988. Chelsea Green (distributed by Milestone, Vancouver). xvii + 187 pp., illus. $23.95.

This book is both an autobiography and an account of the observations of one of the most observant bird behaviorists of our time. Lawrence Kilham tells us that he disliked school until he was "turned on" by reading Emerson, Thoreau, and Ben Franklin. One of his chums was Maurice Broun, who later became known for his work at Hawk Mountain, Pennsylvania. When Kilham entered Harvard as a freshman in 1928, he was fascinated with the Museum of Comparative Zoology and went on all-day birding expeditions with the master popularizer of birding, Ludlow Griscom. Later he switched from zoology to history (under Samuel Eliot Morison) and literature (under Bernard De Voto), and then came under the influence of Hans Zinsser, Professor of Bacteriology, who inspired him to enter Medicine. After graduation and internship, he married a fellow doctor, and the two of them went overseas with the Harvard American Red Cross Field Hospital, over a year prior to Pearl Harbour and America's entrance into the war. After four postwar years of virus research under Dr. John F. Enders, who later won a Nobel Prize, Kilham moved to the National Institutes of Health at Bethesda, Maryland. In 1961, he moved to the Dartmouth Medical College in Hanover, New Hampshire.

At the age of forty, fortified by his incredibly rich and varied intellectual background, Kilham resumed birdwatching in earnest. He began, as he says, to watch everything. After he had recorded his copious notes, he would read up on each bird. Although he preferred to discover everything for himself, he then wished to see what others had observed. The following, to me, are among his key sentences: "Observing makes reading mean more, and reading, when it generates ideas, makes you a better observer." "Going over notes can generate ideas." "Note-taking makes a good observer."

Wherever Kilham worked and taught, whether at Bethesda, in New Hampshire, in Montana, or Uganda, he and his wife, Jane, watched nature. Often they picked a good spot and just sat still. As a behavior watcher, he found that common birds made good objects for study. He enjoyed comparing differences between different species of the same family, especially the various woodpeckers. Although he published many scientific articles and three books, his studies were "more than just a scientific exercise. Spending hours in quiet, beautiful places can provide a return to health and sanity . . ."

Although a scientist by vocation and by avocation, Kilham decries "the chart- and table-studded articles . . . in the leading journals" which rely on "statistics and methodology rather than on prolonged and careful observation." Kilham enjoys observing the characteristics of individual birds, even though "hard-nosed scientists" would dismiss this as anthropomorphism. He seeks out beauty, even though a scientific colleague told him there was no such thing.

The highlights of a lifetime of observation make for interesting reading, as the topics shift from crows to anhingas, from woodpeckers to kingfishers, from muskrats to beavers. Most interesting to me is his observation of a whip-poor-will flying with its egg between its feet. With his background, it is not surprising that Kilham has the gift of writing well. If you have an interest in behavior-watching, this book will be an inspiration.

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Handbook of Mammals of the North-Central States

By J. Knox Jones, Jr., and Elmer C. Birney. 1988. University of Minnesota Press (distributed by Beaverbrooks, Markham, Ontario). 346 pp., illus. Cloth $43.50; paper $23.50.

This book has been designed as a handbook of the mammals of the seven "north-central" states for use by field personnel, with an emphasis on an introduction to mammalogy and an identification guide.

Each of the 104 mammal species that currently live in the north-central states or lived there in the past are covered in this book, with a detailed one page text that includes distribution, description, natural history, and selected references. The accompanying face page details a North American range map, an expanded north-central states range map, and a black-and-white photograph.

The volume contains many useful aids. The range maps, although by their nature general, present useful information on relative distribution. The maps are redundant for ubiquitous species such as the Beaver and Little Brown Myotis, but are useful as a reference for mammal ranges in adjacent south-central Canada. The identification key presented for each Order appears to be very thorough, and will prove useful to field researchers. There is an obvious geographic limitation to the key — species occurring outside of the study area may not be included.

The selected study area itself is somewhat puzzling. The seven states included are not ecologically similar and are geographically diverse, ranging from coniferous forest to deciduous forest to grassland, from Great Lakes to plains. While many maps of the study area are included, there is none that relates the study area location to the American or North American context, or even to name and locate the seven states. While it is perhaps not unreasonable for the authors to assume the location of the states is well known, this will limit its relevance to more distant or geographically naive users.

The book begins with several chapters describing the physical, biological, and human environments of the study area, relating the environmental factors to the distribution and diversity of mammal species. Much of the information is extremely technical, particularly in the discussion of soils and glacial history. While of obvious value to student and researchers, the information is too detailed for general readers and those in search of a field guide; inclusion of this section at the beginning of the text also tends to reduce the impact of the book — we tediously learn about the environmental considerations prior to learning about the mammals themselves.

Each species is accompanied by a black-and-white photograph, generally taken in a natural setting or, for some of the smaller mammals, as a study skin. While the photographs are very interesting, in many cases they are not useful for showing diagnostic identification features, thus reducing the value of the book as a field guide. The rare black-and-white sketches are good, illustrating key skull characteristics, differences between White-tailed Deer and Mule Deer, etcetera. There is a very useful glossary of mammalogy terms included.

This book is essentially an expanded field guide and a brief mammalogy text. It has obvious application to biology students and field researchers/managers within the seven state study area. More life history information is provided than in typical field guides, and the valuable identification keys compensate for the lack of detailed diagrams. The book is larger than a typical field guide, limiting its portability. The application of the book outside of the designated study area is limited. It is of value to those jurisdictions abutting the boundaries, providing indications of what species could be expected to range into that area. However, it cannot be recommended as a more general and comprehensive reference text, due to its several limitations.

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Mammalian Dispersal Patterns

Edited by B. D. Chepko-Sade and Z. T. Halpin. 1987-. University of Chicago, Chicago, Illinois. xviii + 342 pp., illus. Cloth U.S.$55; paper U.S.$19.95.

Sixty years ago evolutionary biologists (including Sewall Wright to whom this book is dedicated) drew together the previously disparate fields of taxonomy, ecology, genetics, and ethology into what Julian Huxley dubbed "the modern synthesis". Evolutionary biology and allied disciplines have prospered within this framework ever since. The present work illustrates that the framework continues to be useful by examining mammalian dispersal patterns as the outcomes of ecological, social, and genetic factors. Based on a syposium, the volume brings together long-term field studies with the work of population geneticists. The six parts of the book consist of an introduction; a section on empirical studies of dispersal with known individuals; two on demography, dispersal patterns, and genetic structure; a set of mathematical models of population structure; and a concluding chapter. In his admirable introduction, W. Shields scrutinizes causal connections of dispersal and mating systems. Setting a background of definitions and approaches, he examines the need to reconcile the conclusions on the genetic advantages of dispersal versus philopatry by examining genetic and somatic consequences, and contrasting defence of mates in mammals with defence of resources in birds. The resulting overview highlights problems of discriminating hypotheses and uncovering proximate and ultimate causation.

The empirical studies review dispersal in deer, wild horses, bear, mongoose, and a number of rodents. (Inclusion of bats and aquatic mammals would surely have broadened the focus and provided interesting comparisons with non-mammalian species.) Trapping and radiotelemetry provide the basic methodology in these studies. Dispersal depends on many factors including the sex and age of the animal, social conditions and the mating system, and the size of the population. Reexamination is required for traditional explanations involving the role of social interactions, especially aggression, as a proximate cause of dispersal, or its function in avoiding inbreeding or decreasing competition for mates.

The two sections on demography and related topics in rodents, rhesus monkeys, and two human populations indicated the full intricacies of individual, social, and demic processes. Especially noteworthy among this research are the experiments by M. Gaines and M. Johnson manipulating hormonal levels of individuals in populations of *Microtus*. Such direct manipulation of the behaviour of animals is clearly needed to go beyond the inevitably correlational nature of observational data. Some of the chapters present complex statistical models, reflecting the theoretical sophistication which can now be brought to bear on data. The efforts are not straightforward, as witnessed by the unexpected difficulties encountered in the multidimensional extension of the method of life tables to subdivided populations. In his contribution, A. Templeton compares inbreeding depression (resulting from mating in small populations) with outbreeding depression (resulting from the disruption of coadapted gene complexes) and illustrates how available data reflect natural outbreeding. In the model by M. Wade and F. Breden, correlated changes in the frequencies of genes are found, including intriguing positive feedback between social and demic features.

The concluding chapter examines the effects of dispersal and social structure on the effective size of populations, on the argument that the calculation of this size for the various cases presented earlier enables a comparison of evolutionary potentials in species with different social and genetic structures. (The rationale for dealing with this particular aspect could usefully have been strengthened.) The importance of demic size, ratio of the sexes, temporal variation, and production of progeny are considered. Overall, effective size of population is quite low, with the studied species having subdivided populations and consequent inbreeding. Guidelines for future field work are helpfully included.

This book provides valuable information and conjectures on the issues under cosideration. While much of the material is limited to a small set of species, many topics of general importance are also touched on, including implications for wildlife management and zoos, and the persistance of problems such as the measurement of biological fitness in natural populations. The necessity for clear definitions, explicit theoretical models, and copious data is obvious throughout. Even among the narrow range of species examined, philopatry and dispersal take on many different forms. The worth of this volume is enhanced by the critical attitude of most of the chapters, including the contrasting and testing of rival hypotheses, and the lucid presentation of the material. Particularly for mammalogists and population biologists, the book will be important reading.

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Guide to the Mammals of Pennsylvania

By Joseph F. Merritt. 1987. University of Pittsburgh Press, Pittsburgh, Pennsylvania, 15260. xviii + 408 pp., illus. Cloth U.S. $34.95; paper U.S. $14.95.

As is often the case with state or regional guides, this one is written for the "broad audience" including professionals and the general public. The author has successfully met this challenge in addition to producing a highly readable and informative work. Features setting this book apart from similar guides include color photographs (of 17 species), easy-to-read range maps for both Pennsylvania and North America, and a section depicting the tracks of 31 of the state's 38 genera of terrestrial mammals.

The 63 species accounts include the usual descriptive data, a black-and-white photo of most species, and sections on ecology, behaviour and reproduction. Comments on status in Pennsylvania are provided for those species judged to be endangered, threatened, vulnerable, or of undetermined status in the state. Ten additional species which have been extirpated or are of uncertain occurrence in the state are also discussed. A brief introduction to each order and family helps to describe and place these taxa, especially for readers unfamiliar with the broader scope of mammalogy. For each family, a representative skull is shown in lateral, dorsal and ventral views. Curiously, a local genus is used for each family except the Soricidae, for which *Crocidura* is shown.

Sections on the characteristics of mammals and Pennsylvania habitats precede the species accounts and an appendix includes brief comments on the observation of wild mammals, the section on tracks, and a table of dental formulae. There is an adequate glossary and one references section subdivided by subject (e.g., field guides, Pennsylvania environments) and taxonomically by family. for many users or potential users of this book, the lack of keys to either skins or skulls will be a serious omission.

Overall, this attractive book is informative, clearly written, and has been effectively edited (I noticed no typographical errors). It should be especially useful in Pennsylvania, but deserves a wider audience as well.

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The Kookaburras' Song: Exploring Animal Behavior in Australia

By John Alcock. 1988. University of Arizona Press, Tucson. x + 200 pp., illus. U.S. $19.95.

John Alcock is well known as a researcher in the behavioural ecology of insects and the author of a successful text. He is a vigorous adaptationist, believing that the characteristics of organisms (be they morphological, physiological, or behavioural) contribute to the production of surviving offspring. In the present work Alcock groups 27 essays, dealing primarily with endemic mammals, birds, and insects, under five headings: On Adaptation, Nuptial Puzzles, Machismo and the Competitive Male, Primitive or Degenerate, Life with Others, and Adaptive Altruism. Amid travelogue narrative and accounts of cockatoos, wallabees, and weaver ants, he illustrates the interest of behavioural ecologists and evolutionary biologists in a wide assortment of topics including animal communication, the functions of sex and mating systems, the nature of territoriality, patterns of reproduction and parental care, phylogenetic trends, radiation of species, and evolutionary convergence. There are suggested readings and an index, and the useful illustrations include range maps of the species under discussion.

This book belongs to the venerable didactic tradition of providing lessons in biology in the form of entertaining vignettes. The nineteenth century produced such conversational volumes as "Dialogues between Mrs. Dinsdale and her two Daughters" while a host of contemporary writers, pre-eminently Stephen Jay Gould, whose criticisms of adaptationism have often led to a crossing of literary swords with Alcock, provide zesty essays on diverse subjects.

Alcock's essays afford easy reading and serve as a light introduction to both the natural history of Australia and focal points of current research activity. Appropriately for a book which takes an evolutionary perspective, it is printed, as the cataloguing information assures us, on "alk. paper". The view of Australia presented is a purely terrestrial one, and it is perhaps surprising that aquatic highlights such as stromatolites and the Great Barrier Reef, which Alcock visited, are not included. The description of a honeyeater as having a sweet tooth also gives pause. Overall the book succeeds as a popular introduction to Australian wildlife and issues in contemporary field biology.

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Atlantic Fishes of Canada

By W. B. Scott and M. G. Scott. 1988. Canadian Bulletin of Fisheries and Aquatic Sciences No. 219. University of Toronto Press, Toronto. xxx + 731 pp., illus. $45.

Atlantic Fishes of Canada is the long-awaited replacement for Leim and Scott's *Fishes of the Atlantic Coast of Canada*. It was well worth waiting for. The new volume includes 538 species (all but 10 treated in the text), as opposed to about 290 species in the earlier work, and contains 246 more pages. Information is increased for a number of species.

The book is divided into a Forward; Background information (Introduction, Acknowledgements, Review of fisheries and fisheries research, Oceanography, Area covered, Species account, and How to preserve specimens); Family and species accounts; Checklist; Keys; Glossary; Abbreviations; Metric conversion tables; Information on specimens illustrated; References; and an Index to names.

The Background Information section is a mine of information. I learned that commercial fisheries contribute over a billion dollars to Canada's economy, that there are over 50 000 registered fishermen on the Atlantic coast, that the overall Atlantic coast catches peaked in 1968-69 at 3.5 million tonnes but have declined to less than 2 million tonnes in 1985. Fishing technology innovations and changes in surveillance are described. The list of regional fisheries research stations omits the Institute Maurice-Lamontage. The oceanography of the region is summarized in two pages. The full species account is outlined: Biology (Habitat, Reproduction, Growth, Food, Predation and competition, Parasites and disease), Distribution, Relation to man, Description, Systematic notes, and common names. Abbreviated accounts are used for rare and unusual species, or those that are known only from larvae. Instructions on preservation conclude this section. A discussion of pollution, habitat loss, and conservation would have been desirable — e.g., conditions in St. Lawrence estuary and Halifax Harbour.

The bulk of the text, some 570 pages, is occupied by accounts of families and species. Most species accounts include a black-and-white drawing or photo of the species, and, for the important commercial species, a shaded distribution map is appended. Occasionally an additional figure is added — eggs of the Hagfish, nest of the Ninespine Stickleback, or a herring weir; these add to the esthetics of the book.

The Scotts do not support the reported Canadian record for a 11.28 m specimen of the Great White Shark, *Carcharodon carcharias*, reported from near Grand Manan. They do report valid Canadian records of the species including one from Deer Island, New Brunswick, that had three porpoises in its stomach.

Thanks to the activities of the Huntsman Marine Laboratory and other agencies, a number of new records based on larvae are recorded for Canada for the first time, e.g., many new lanternfish records. Scott and Scott recommend against exploitation of lanternfishes as human food as these fish serve as prey for many commercial fishes, as well for seals and whales.

The Scotts are known and widely quoted for their thorough summaries of biological information in *Freshwater Fishes of Canada*. Many accounts in *Atlantic Fishes of Canada* are up to that measure (others because of space or lack of information are shorter). From their account of Atlantic Argentine, for example, I learned that they probably spawn in March and April in Canada, and lay as many as 38 599 buoyant eggs up to 2.8 mm in diameter. Specimens may reach 29 years in age, though the largest specimen is only 49 cm long. Argentine feed on euphausiids or amphipods, rarely on small nekton or plankton. Although plentiful, delicious and nutritious, Canadians do not fish the Argentine. Instead, they are caught by foreign fleets.

The text is very readable and generally impeccably accurate. A rare omission or flaw occasionally creeps in. The white stickleback, an undescribed Nova Scotian species, is omitted, perhaps because of the recency of its discovery. Gill rakers do not number 43 in the Greenland Cod (better called in my view *Ogac*), but 19-22 (*fide* Claude B. Renaud who is completing a thesis on taxonomy of *Gadus*). A specimen of *Coregonus huntsmani* Scott, an endangered species, collected in the estuary of the Petite Rivière, Nova Scotia, and others occasionally reported there, suggest that there may be a tiny anadromous population surviving in that river, although they might represent expatriates washed down from the lake populations upstream. Bottom samples suggest that *Melanostigma atlanticum*, may inhabit burrows in the mud. The species called by Scott and Scott, and most previous authors, *Sebastes marinus,* should correctly be called *Sebastes norvegicus*. A character I have found useful in distinguishing *Myoxocephalus aeneus* from other sympatric species of the genus is the rather stiff first dorsal spines.

The book is well edited, the typography and layout is agreeable, the matte paper is superior to the usually glossy stock, and the book is well bound. Editors and publishers have done a commendable job. The illustrations are on the whole good. But the drawings do represent a variety of styles and are mixed with photos. Should the government have provided funds for a series of standardized illustrations for a book involving a billion dollar industry?

Scott and Scott's *Atlantic Fishes of Canada* is an especially fine faunal work and a great addition to our knowledge. It is very readable, provides authoritative summaries of data, and includes much new information. The Scotts can indeed be proud of this valuable reference.

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The Empidoidea (Diptera) of Fennoscandia and Denmark. II. General Part. The Families Hybotidae, Atelestidae, and Microphoridae

By M. Chvála. 1983. Fauna Entomologica Scandinavica, Volume 12. Scandinavian Science Press Ltd., Copenhagen, Denmark. 279 pp., illus. 200 D.kr.

Empidoid flies include a diverse array of voracious insect predators, such as balloon flies, dance flies, and long-legged flies that together form a conspicuous and economically important portion of the Canadian insect fauna. Over the years this diverse group, of approximately 8000 species world-wide, has also attracted considerable attention from ethologists interested in the wide range of courtship and mating behaviors these flies display, which may include curious ritualized transfers of nuptial gifts or prey.

In this work Chvála continues his revision of the Scandinavian species formerly placed in the single family Empididae, with the subfamily Tachydromiinae having already been revised in Volume 3 of the same series in 1975. This revision treats the remainder of the former Ocydromioinea-group of subfamilies, namely the Atelestinae, Microphorinae, Ocydromiinae and Hybotinae, in the same competent fashion as in the previous tachydromiine volume, with concise keys and detailed descriptions accompanied by copious illustrations. Treatment of the remaining Scandinavian taxa, the former Empidoinea-group of subfamilies, which include the Oreogetoninae, Brachystomatinae, Empidinae, Hemerodromiinae, and Clinocerinae, is promised by the author in future volumes of Fauna Entomologica Scandinavica. Given the close similarities of the Scandinavian and Nearctic empidid fly fauna, especially at the generic level, the completed series will certainly be welcomed by all North American specialists and students of empidoid Diptera alike.

The present work is of interest to non-specialists however, because Chvála begins with a general section that encompasses nearly a third of the book. In this section extensive morphological and systematic evidence, including a review of the known Mesozoic fossil data, is presented as part of a cladistic analysis of the higher taxa of the Empidoidea. In addition, life history information of both adults and immatures is briefly summarized, including phenology, feeding, swarming, and mating habits.

Based on his phylogenetic analysis, Chvála reclassifies the superfamily into five families (Empididae, Hybotidae, Atelestidae, Microphoridae, and Dolichopodidae), rather than just the two (Empididae and Dolichopodidae), generally found in more traditional schemes. Subdivision of Empididae in the traditional sense has been suggested by dipterists in the past, given the realization that the group is paraphyletic at least in relation to the speciose Dolichopodidae. Although the work is certainly a tremendous advance in this direction, Chvála's phylogenetic conclusions must still be considered quite tentative. Southern hemisphere taxa were not generally considered in the analysis, although *Homalocnemis* (Brachystomatinae) and *Ceratomerus* (Ceratomerinae) were examined, and some of the new family concepts appear weakly supported. For instance, the Microphoridae are shown (Figure 142) to be paraphyletic in relation to the Dolichopodidae, and the monophyly of Empididae in the new restricted sense is not supported by any convincing shared derived characters (Figure 142 and page 65), indicating that this group may be paraphyletic in relation to one or several of the remaining empidoid lineages. In addition, spermathecal number and structure of the male genitalia together suggest that Chvála's placement of only the Atelestidae (rather than the entire Empidoidea) as the sister-group to the Cyclorrhapha (the remainder of the higher flies) may be incorrect, requiring further consideration of the exact relationships and ranking of this empidoid group. Until the phylogenetic relationships of these component lineages are more fully understood, it would be better in my opinion to continue to formally recognize a broad traditional, albeit unnatural, concept for the family Empididae.

In summary, this book provides an excellent comprehensive treatment of the remaining Scandinavian members of the Ocydromioinea not covered in Chvála's earlier tachydromiine volume. However, with the inclusion of a very extensive general part covering the Empidoidea as a whole, this work is of interest to a much wider audience than only those systematists studying Scandinavian empidoid flies. For example, the interpretation by Chvála that males of many members of the presumed basal lineages of the Empididae *sensu lato* possess expanded gonocoxites dorsally while retaining a true epandrium (9th tergite), is a notable addition to an important on-going debate in the literature concerning the homologies of the male terminalia of higher flies. By providing a preliminary phylogenetic framework for the Empidoidea based on a detailed analysis of structural characters, Dr. Chvála has set the state for further studies on this interesting group of flies. Even though this book was published a few years ago, I highly recommend it to anyone interested in Diptera classification.

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Nymphs of North American Stonefly Genera (Plecoptera)

By Kenneth W. Stewart and Bill P. Stark. 1988. Thomas Say Foundation Volume XII, Entomological Society of America, Hyattsville, Maryland. xiii + 457 pp., illus.

Stoneflies are common and widespread aquatic insects familiar to the entomologists, aquatic ecologists, and fly fishermen around the world. A moderately sized group in terms of number of taxa (approximately 550 species in North America), Plecoptera are excellent subjects for the study of systematics, biogeography, and ecology. For these reasons, several important taxonomic works have appeared over the years dealing with large segments of the North American fauna. In the past three decades, however, wholesale changes have been made in stonefly taxonomy, numerous previously unassociated and unknown taxa have been reared, and new characters for separating genera and species have been discovered. As a result, the classic earlier texts are now outdated and it has become difficult to keep abreast of all the changes. Recently published keys and summary checklists have helped but are less than completely satisfactory because they lack sufficient detail. Now, all that is changed. *Nymphs of North American Stonefly Genera* provides the most authoritative treatment of stonefly systematics and the most usable keys to the nymphs that are available. It covers all 99 genera known from North America north of Mexico with keys, detailed diagnoses, descriptions, illustrations, and lists of all described species with their known distributions.

The book is organized into two sections. The first five chapters provide an introduction to the book itself, an introduction to stonefly classification, phylogeny, and biogeography, and a review of the ecology and behavior of the nymphs. Chapter 4 on nymphal ecology and behavior is the best review of these topics currently available. Included are discussions of life cycles, growth, and food habits, stonefly-substrate relationships, and secondary production. The chapter concludes with a novel section on stream management strategies that might enhance stonefly populations. Operating on the assumption that stream management is usually directed toward enhancing fish populations and that the success of fish populations depends upon the success of their food supply, the authors argue that any management activity that serves to enhance stonefly populations must also ultimately enhance fish populations. This may well be true, and in fact it may be worthwhile in certain circumstances to investigate the utility of some of the suggestions for habitat modification made by the authors. But I absolutely oppose the suggestion that it may even be desirable to introduce species to a stream that is outside the normal geographic range of the species. Over and over again, accidental as well as intentional introductions of exotic species have proven to be unwise, at best, and disastrous all too often. There is always a better alternative.

The systematic section of the book begins with a key to the nine North American families (Chapter 6), which is followed by separate chapters (7 to 15) on each family, and concludes with a complete summary of all the generic nomenclatural and taxonomic changes of the past 30 or 40 years. Each family treatment begins with a discussion of the taxonomic history and the current state of knowledge of the genera. This is followed by the key to genera, which represents one of the great strengths of the book. The keys work extremely well, even with difficult separations as are encountered in the Chloroperlidae, for example. The authors use a number of new characters that make distinguishing genera simpler than previously was possible. I felt more confident of my identifications using these keys than I ever felt using other keys.

Following the keys, each genus is treated separately in detail. There is a historical perspective of the included species with a list of previous descriptions of the immature stages, a complete morphological description and diagnosis including significant variations of characters within and among species, illustrations, and a review of nymphal biology. Each generic treatment ends with a species list with the range of each species by state and province.

The illustrations consist of a full-page habitus drawing of a nymph in dorsal view, followed on the next page by numerous detail drawings. It is this set of drawings that represents the only weakness in the book — although of high quality and appropriateness, most of the detail drawings are simply too small to the show the characters of interest. Every page of detail illustrations includes a drawing of the head and pronotum which frequently is referred to in the keys or the descriptions. Unfortunately, these detail drawings are usually no larger than the corresponding features on the habitus drawing and, in fact, frequently are smaller. When the primary purpose is to show variations in color patterns this is not a serious problem, but more often the characters of importance are setal patterns which often cannot be distinguished. This is too bad, but even so, I don't feel that this is a serious problem when considered in the context of the book as a whole.

All in all, *Nymphs of North American Stonefly Genera* is a marvelous book. Everyone who has occasion to identify stonefly nymphs, all aquatic entomologists and ecologists, and even sophisticated fly fishermen, should have a copy. It is the best resource there is for North America, and it is likely to be the classic reference for years to come.

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BOTANY

Atlas of the Rare Vascular Plants of Ontario, Parts 1-4

Edited by George W. Argus, Kathleen M. Pryer, David J. White, and Catherine J. Keddy. 1982-1987. Botany Division, National Museum of Natural Sciences, Ottawa. Pages unnumbered. $5 postage.

In 1977 George W. Argus and David J. White of the National Museum of Natural Sciences published a list of rare Ontario vascular plants (species, subspecies, and varieties) based on a reconnaissance of herbarium records and correspondence with field botanists across the province. This preliminary publication initiated a 10-year program that has culminated in the publication of the fourth and final part of "The Atlas", as it has become known to Ontario botanists. It also encouraged the development of a series of studies which have treated the rare flora of every Canadian province and territory, save Prince Edward Island and Newfoundland.

Each part of the Atlas was produced in loose-leaf format, so that additions and up-dates could be added later (although there have been few of the up-dates). Each species write-up is treated as a distinct publication. All told, 66 individual authors were involved, describing 543 provincially rare plants. In addition, another 398 taxa were considered but ultimately rejected, for reasons listed in tables at the beginning of each family section. These remarkable figures attest to the exceptionally thorough and careful effort that went into the production of the Atlas.

With the final part of the Atlas, the editors included a preface that suggested ways readers could amalgamate the various pieces into a unified volume. (I have found it convenient to put the dicots all in one large three-ring binder, arranged alphabetically by family, with the monocots, gymnosperms, and pteridophytes in another, smaller binder).

An up-dated introduction reviews the data fields, councils interpretive approaches, and includes a large "References Cited" which covers all four parts of the Atlas. Several valuable appendices follow: a list of the (mostly) Canadian herbaria examined, including private collections; a list of rare plant data sources from other provinces and states in the United States; a list of contributors (including their addresses — a helpful feature); and a list of excluded species that belong to families with no rare plants in Ontario. A very complete index, including rare and excluded taxa as well as synonyms, ends the introduction. This index is helpful but a bit hard to get onto at first; I found the three type faces used to be distracting. (The index is not needed often, however, if species are filed in some form of alphabetical arrangement as described above).

Each taxon is treated in the same manner, including Ontario and North American distribution maps. These are all original products of the Atlas, based on literature and herbarium sources (all cited). A brief synonomy, rare status elsewhere in North America, habitat preferences, and, in many cases, miscellaneous notes on specimen records, taxonomic questions, identification, and the survival threats to the species, follow. Pertinent literature citations and the author(s) name(s) concludes the treatment. With so many authors involved there is a certain degree of variation in the depth and emphasis of coverage, but this is remarkably minor, all things considered.

These are terrific little papers; succinct, descriptive and accurate statements on the status and situation of Ontario's most uncommon flora prepared, in most cases, by the person(s) most knowledgeable about that taxon. Technical and typographic errors are very few, again remarkable, considering the tens of thousands of bits of data which were managed.

Readers may question the inclusion of some taxa (count me among those who would exclude *Panax quinquefolium*, and *Solidago sempervirens*, for example), but that is inevitable. Wherever the lines are to be drawn (and Argus et al. provide clear definitions of these), there will always be some judgement calls. The editors have done remarkably well with their choices, especially considering the number of authors involved.

A surprising feature, in these tight-fisted times, is that Parts 1, 2 and 3 were distributed free and Part 4, only for the cost of mailing, thus ensuring a wide and effective distribution of these valuable data.

And these data *have* made a difference. Being able to cite the authority of the Atlas for the status of *Oenothera clelandii,* for example, helped botanist Jocelyn Webber successfully lobby the City of Mississauga to acquire a small relict prairie for its protection from a proposed urban development.

So congratulations to George Argus and his fellow editors, and to the National Museum of Natural Sciences, for the production of a vitally needed, technically sound, widely accessible and very effective life sciences data base. In these days when more and more floristic inventory is considered to be unscientific and of low priority, the National Museum of Natural Sciences has shown what truly important ends such data, carefully gathered and evaluated, can be put to in the effort to protect and appreciate our national natural heritage.

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The Evolution and Classification of Flowering Plants

By Arthur Cronquist. 1988. Second edition. New York Botanical Garden, Bronx. ix + 555 pp., illus. U.S.$45.35 in U.S.A.; U.S.$46.80 elsewhere.

The first edition of this book, which appeared in 1968, was clearly aimed in part at students, the taxonomic outline being preceded by 122 pages of introductory matter. It was followed in 1978 by a reprint that included a 2-page addendum in which various taxonomic changes were made. In 1981 Dr. Cronquist published a large, more detailed work: *An Integrated System of Classification of Flowering Plants.* This book had no introductory chapter, but representatives of most families were illustrated.

Now we have a completely new edition of the 1968 book. The taxonomic outline includes changes, from 1978 and 1981 (and a very few more recent ones); but the format is not conspicuously altered. It will be extremely valuable to those of us who must frequently check the disposition of families or orders. The new edition is some 160 pages longer than the original, most of this growth being in the introductory chapters totalling 258 pages. These chapters provide a short course in evolution and taxonomic methodology, and should be read carefully by serious students of systematics. We senior citizens can also benefit from them, but they cannot be discussed critically in a short review. As far as I have gone into them, I find myself in general agreement with Cronquist; but no two students would agree implicitly with all points treated. A notable, and to me delightful, addition is the inclusion of portraits of many leaders in plant systematics, both pioneering and recent, and also those two great evolutionary zoologists, George Gaylord Simpson and Ernst Mayr. I am happy to see again many helpful colleagues.

Some points may be noted concerning the classification. In addition to the selected references given for each subclass or order, more general references are listed on pages 267-268. Considerably more attention is given in this edition to ages of origin; and I was glad to find a geological time scale on the back flyleaf, for some of the minor stages of the Cretaceous Period are hard to remember.

As in 1981, Laurales are segregated from Magnoliales. Cronquist again emphasizes the proximity of Berberidaceae to Ranunculaceae but without specifying the connecting genera. (I am intrigued because the rust genus *Triphragmiopsis* has only two species, one on *Isopyrum* and one on *Jeffersonia*). Hamamelidales are still regarded as basal in Hamamelidae, although the two known rusts of Hamamelidaceae are conspicuously more modern than those of Fagales and Myricales. Under Rosidae, I am relieved to see Fabales removed from Rosales, which are complex enough without them. Some fossil dates are given for Fabales, but it may be noted that the geographic patterns of the mimosoids and their rusts insist on an age of ca. 90 million years. Celastrales are slightly modified from 1981 by insertion of the recently described Tepuianthaceae. Umbellales and Umbelliferae are corrected to Apiales and Apiaceae — hopefully the last to be seen of the irregularly formed names. Under Campanulales, the small family Donatiaceae is segregated from Stylidiaceae as in 1981; and Dipsacaceae is modified by transfer of Calyceraceae to its own order. The evolutionary diagram for Asteridae is from the 1981 volume. It indicates a basal split in the subclass even more emphatically than the 1968 one, but its basis is not very clear. The whole subclass seems to have originated in early Tertiary, and Asteraceae in the Oligocene period.

The classification of the monocotyledons (Liliopsida) closely follows the 1981 treatment, and the relationship diagrams are identical. One innovation is the recognition of septal nectaries, which, although not universal in monocots, are apparently peculiar to them and help to unify the class. Septal nectaries occur in the septa between two carpels and represent places where the adjacent walls of the carpels have not fused. They are said to be such complicated structures as to suggest a relationship between all plants having them. They may open at the base of the ovary, at its top or even in the style. The classification differs from that of 1968 principally in recognizing a subclass Zingiberidae, containing Bromeliales and Zingiberales. As in 1981, firm early dates are given for monocots back to Aptian-Albian time; and the wide variety of leaves from late lower through upper Cretaceous indicates their extensive radiation. This information dovetails with the known occurrence of two bambusoid genera in Madagascar and India, indicating an 80 million year minimum age for the subfamily.

Under Arales, *Acorus* is removed from Araceae, surely correctly, but dubiously disposed in the adjoining family Acoraceae. However, *Acorus* not only shares a rust with *Sparganium eurycarpum* but also shares several morphological characters exclusively with it, and surely must be placed in Sparganiaceae — a disposition I would hesitate to suggest until its manifold discordance with Araceae was presented. Turning to Commelinidae, I find the 1968 treatment of Juncales and Cyperales still maintained. I sympathize with Cronquist in his dislike of monofamilial orders, but they may be unavoidable (as in Asterales); and they are preferable to a misleading simplification.

Juncaceae is firmly tied to Cyperaceae by their diffuse centromeres (in all species examined) and by parasite data. In fact, rust data indicate that Juncaceae evolved out of lower Cyperaceae through a partial (perhaps not very successful) reversion to entomophily. Poaceae are distinguished from Cyperaceae by their normal point centromeres and by many distinctions in their parasites. I see no alternative to putting Poaceae in its own order. *Thurnia* should be examined cytologically, but I shall be surprised if it proves to be linked to Juncaceae.

In Poaceae, I find it difficult to avoid recognition of Arundinoideae and Chloridoideae. Oryzeae are so distinct in floral morphology and their rusts that it probably is a valid subfamily, which is better than stuffing it into a catchall supertribe of Bambusoideae. Dating of typical grasses is problematical; but among the bamboos, *Ochlandra, Schizostachyum*, and *Cephalostachyum* (perhaps a section of *Schizostachyum*) occur in Madagascar and India, and must date from before the movement of the Indian craton 80 million years ago. Cronquist maintains a broad concept of Liliaceae, which seems preferable to extreme splitting. As long as Allioideae and Amaryllidoideae are recognized as widely separated, I am content.

In closing, I may point out that much of the pertinent mycological data can be found in *Botanical Review* 45 (4), 1979.

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Encyclopedia of Ferns

By David L. Jones. 1987. Lothian (distributed by Timber Press, Portland, Oregon). xvii + 433 pp., illus. U.S.$55.95.

All encompassing titles like that of this book often indicate that the volume is a superficial review, covering lots of ground but none of it deeply. Happily, this book goes against that trend and does remarkably well in justifying its ambitious title.

David Jones is an Australian horticulturalist who has wide botanical interests. In *Encylopedia of Ferns*, he attempts to pull together a comprehensive picture of fern culture around the world, both to stimulate interest in their cultivation and to increase appreciation for them as an intriguing group of plants. To do this, he begins with a review of the standard introductory sections (fern structure, reproduction, economic importance, etc.), and then summarizes the classification and life cycles of each of the world's major fern groups. Only then does he embark on a series of lengthy discussions of fern cultivation, pest and disease control, propogation, and fern hybridization. All of these are well done.

But that is only half of the book. In the other 200-plus pages, he provides a family-by-family discussion of about 700 species and forms known in cultivation around the world, each with a brief range and habitat description and horticultural prescription. That is followed by a series of appendices which group ferns by ecological or horticultural characteristics, then by an excellent glossary of terms, followed by a list of major literature references, and finally, by a list of fern societies around the world (nine in Canada). These sections are also expertly and clearly presented.

In addition to a rich and interesting text, the book includes over 400 photographs of ferns and their structures as well as numerous clear and precise line drawings. The photos, half of which are in colour, are outstanding and explicit.

This ambitious volume is not without its glitches; the type-face used, for example, is uncomfortably small — no doubt employed to keep down costs. Perhaps the use of slightly lighter paper stock and a larger type face would have worked better. The author's experience is predominantly in the southern hemisphere and this shows in a rather imprecise definition of ranges and status for many North American taxa. *Lycopodium selago*, for example, is not confined just to montane regions of North America. And I must assume that it is an artifact of the production process and not an error in the author's understanding, that repeatedly lists Canada and North America as separate geographic entities (e.g., in range description of *Athyrium felix-femina*)! While the nomenclature is quite up to date for most Canadian taxa, I would have preferred to have nomenclatural authorities added to botanical names throughout. There seem to be remarkably few technical errors, although a line of text is missing between the bottom of page 91 and the top of page 92. I also question some of the listings in Appendix 8, Cold-hardy Ferns. Jones indicates that *Adiantum capillus-veneris* is very hardy, which it certainly is not, growing only as a rare hot springs' margin plant in the northern half of North America. Conversely, he suggests that *Woodsia ilvensis* is not particularly frost and snow hardy . . . a difficult conclusion to accept for a plant that grows north to Baffin Island and Greenland.

Coverage of this huge group of plants, with 10 000 to 12 000 species in the world including such diverse elements as a species which is used for fence posts in New Zealand, another used as a fertilizer in Southeast Asian rice paddies, and yet another used in the making of beer in India, is a very ambitious task. By and large, David Jones has achieved this objective remarkably well in an attractive, well designed and sturdy volume. The book is aimed primarily at the horticulturalist and the vast store of knowledge and advice that is offered to readers with green thumbs is superb.

If you like ferns as ornamental objects or simply find them to be interesting plants, you will like this book. If you have a fern garden and/or are a frustrated fern culturist (like me!) you will love it and should not be without it.

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Flowers from The Royal Gardens of Kew: Two Centuries of Curtis's Botanical Magazine

Edited by Ruth L. A. Stiff. 1988. University Press of New England, Hanover, New Hampshire. 88 pp., illus. U.S.$15.95.

To honour the bicentenary of their botanical magazine, The Royal Gardens of Kew have loaned 80 original watercolour paintings of botanical specimens for exhibition in the United States. This book is both a festschrift for the magazine and a catalogue for the exhibition.

To celebrate the magazine, there are two full-length essays. One is a biography of William Curtis, the founder of *Curtis's Botanical Magazine* (now called *Kew Magazine*) in 1787. The other essay outlines the history of the magazine, its editors, illustrators, and those who collected plants for Kew. These men and women are legendary botanists, some of them associated with the great explorers such as Darwin, Captain Cook, and Captain Bligh. The names of William and Joseph Hooker, Joseph Banks, and Frank Kingdon Ward are familiar from histories of 18th and 19th century explorations. Plant collecting all over the world by these men and others resulted in the subsequent introduction of new species to Kew and thence to gardeners and nurseries.

Used as a catalogue for the exhibition, the descriptions for each plate trace the history of the plant and even give some basic information on cultivation — useful if you should be lucky enough to acquire, for instance, a blue crocus (*Crocus baytopiorum*), discovered in Turkey in 1973. The reproduction quality of the plates is excellent — though they would have been more suitable for framing if they were not printed back-to-back!

This is a lovely book — particularly suitable for an avid gardener with an interest in the historical and regional origins of some of our garden plants.

The schedule for the exhibition was: New York Public Library, June to September 1988; Missouri Botanical Gardens, St. Louis, October to November, 1988; and Chicago Botanical Gardens, March to April, 1990.

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Plants and the Blackfoot

By Alex Johnson. 1987. Occasional Paper No. 15, Lethbridge Historical Society, Lethbridge, Alberta. 68 pp., illus. $6.95.

The Blackfoot Indians, "so-called because their moccasins were usually black from the soot of prairie fires" at the time the white man first arrived, occupied the northwestern plains east of the Rocky Mountains in what is now southern Alberta, extreme southwestern Saskatchewan, and a large part of Montana.

This booklet records species of some 56 families of plants that were used by this group of nomadic native people, and to some extent, the Crees who were found to their north and east, as well as other tribes to the south and west, for food, medicine, adornment, dyes, etc. The Latin and English names, and, where known, a transliteration of the Blackfoot name, are given for each plant. This is followed by a paragraph on the various uses made of the species, and frequently by interesting comments and anecdotes, e.g., after an old man lost his eyes "He borrowed eyes from the coyote and, as he did not want to leave coyote blind, he put gosseberries into the eye sockets, spat on them, and coyote could see. And ever since, the eyes of coyote shine in the dark and look like gooseberries."

The book is copiously illustrated with paintings by Alberta artist Annora Brown (unfortunately in black-and-white), together with line drawings by A. C. Budd and Keith Best which were previously used in their floristic studies of the Canadian prairies. These are supplemented by a number of photographs, mainly of Blackfoot Indians in action, or of some of their possessions. Also, three maps depicting the area inhabited by the Blackfoot tribes, the floristic zones of the Canadian prairie provinces, and the seasonal movements of a Peigan band in the pre-settlement period, provide additional background information. Scattered throughout the publication are inserts set off in a grey background. They contain interesting and informative comments on such topics as "Berry-fat Cattle", "Medicine Men fill health-care gaps", "Prairie Wool", and "Chewing Sticks".

This work was based on information gathered together from many sources for presentation at field lectures to ranchers and range technicians. Various versions, beginning in 1960 have been published, the most recent in 1982 as Provincial Museum of Alberta Natural History Occasional Paper No. 4, of which the present is a revision. I am sure that anyone interested in the lore of the early inhabitants of this continent, or the uses to which plants may be put, will find it most useful and informative. The word of caution is given however: "To be reasonably sure of the identity of a plant species before you try it is not enough, *you must be certain*!"

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The World of Northern Evergreens

By E. C. Pielou. 1988. Comstock Publishing (Cornell University Press, Ithaca). x + 174 pp., illus. Cloth U.S. $36.50; paper U.S. $10.95.

A glance at any vegetation map of Canada will emphasize how much of the country is covered by evergreen forests. These forests figure prominently in our conception of ourselves as Canadians. Images of Canada as a land of lakes and trees exemplified by many paintings of the Group of Seven or Emily Carr — form part of our collective consciousness. But it is E. C. Pielou's contention that these forests, simply because they do form the background to so much of our lives, are taken for granted and rarely well-understood. To remedy this, the distinguished biogeographer has written a book focussing on the northern evergreen forests. These include not only the extensive boreal forests which stretch from Newfoundland to the Northwest Territories, but also the coastal rainforests of British Columbia, and the coniferous forests of the western Cordillera.

The main part of the book is divided into ten chapters and an epilogue. The chapters fall naturally into three sections. The first section, consisting of five chapters, concentrates on forest development and the characteristics of the main evergreen forest trees. Pielou begins by discussing briefly the origins of the evergreen forests, highlighting the changing nature of landscape and the impact that events such as glaciation and climatic change have had on areas now vegetated by forest. She emphasises the advantages conferred by evergreenness in situations of summer drought, such as that experienced by West Coast forests, and harsh climate, such as that experienced in the boreal forest particularly at its northern limit. This section also includes a short discussion of the physiological characteristics of trees that confer cold hardiness.

Pielou then focusses directly on the recognition and attributes of the trees that compose the evergreen forests. She includes keys for the identification of the various tree genera and species, together with instructions for using them. Linnaean nomenclature for plants is introduced together with a short discussion of the advantages of binomial names and an outline of how the names are derived. Pielou also includes a description of conifer reproduction, and a consideration of some other aspects of the trees' biology, such as the structure and function of wood and bark, and the role of the needles in photosynthesis and transpiration.

The next four chapters comprise the second section of the book. These chapters concentrate on other components of the evergreen forest ecosystem. These include: insect pests and their predominantly deleterious effect on trees; fungi and their role in nutrient cycling; fire and its impact on forest regeneration; mammals and birds and their function in seed dispersal. This section is particularly interesting and contains many examples and illustrations. A significant point made by Pielou in discussing insect pests is how several of them, such as the Larch Casebearer and the Balsam Woolly Adelgid, are not native to the northern evergreen forests of North America but were introduced, probably accidentally, by Europeans. The havoc they wreak is so much more severe because their natural predators were not introduced at the same time. Pielou also stresses that many disturbances, such as fire or snow damage, play an intrinsic role in the development and maintenance of the forest ecosystem. This point is particularly pertinent given the media debate over fire suppression after the recent major fires in the Yellowstone Park region.

The third section of the book consists of just the last chapter, which briefly discusses some deciduous trees, such as alders, birches, and aspens, that may often occur in evergreen forests. Following this, the epilogue highlights Pielou's motivation for compiling this book more explicitly. She appeals for greater understanding of the forest ecosystem. Pielou underscores the difference between natural regeneration of the forest after a disturbance such as fire, for example, compared to the devastation of the whole ecosystem wrought by clear-cutting. She argues that clear-cutting cannot be considered in any way analogous to natural disturbance. Pielou suggests that we should consider managing some areas of forest for intensive tree-production in a similar way to cropped agricultural land, while reserving other forest areas as wilderness. She wants people to understand that "there are no free trees."

Although not stated explicitly anywhere in the text, its very simple style and the abundance of explanation suggests that the book is aimed at laymen or beginning naturalists of any age. It provides a good introduction to the topic of forest ecology. Unlike many nature books, which concentrate on one segment of the biophysical world, such as birds or wildflowers, this book describes many elements of the ecosystem. Pielou continually stresses how all aspects of an evergreen forest exist in conjunction with each other and describes the linkages between them. This holistic approach is refreshing and forms a major strength of the book.

There are few references within the text, but end notes following each chapter provide references to more technical literature for specific points which could be followed up by an interested reader. There is also a list of recommended publications at the end of the book; most of these should be readily available in any public library. The book is illustrated throughout by simple but effective line drawings. Its moderate price makes it available to a wide readership.

Despite the keys in the initial section of the book, this is not really a field guide, but more of a text to browse through before or after a day in the field. Although touching only briefly on numerous topics, this is a book that many naturalists, both novice and experienced, will read with pleasure and interest.

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A Flora of the Vascular Plants of Cattaraugus County, New York

By Stephen W. Eaton and Edith Feuerstein Schrot. 1987. Buffalo Society of Natural Sciences, Buffalo. 235 pp., illus. U.S.$15.95 plus U.S.$1.25 shipping.

Although the title of this work implies it is intended for a limited audience, such is not necessarily the case. Cattaraugus County, in western New York, includes a northern once-glaciated section whose relief was reduced by the Pleistocene ice and which has had a history of farming since European settlement. The southern third of the county with elevations reaching 730 m is at the northern tip of the unglaciated Appalachians. Owing to its location and history, northern, southern, coastal plain, and prairie elements contribute to the county's flora which comprises some 1280 species.

Approximately one-third of the book discusses phytogeography, geology, and soils of the region in addition to a large section titled floristic analysis by habitat. The bulk of the book is an annotated list of species in which data are provided on abundance, occurrence in the county, anthesis and fruiting dates, and whether the species is native or introduced.

This book is a significant contribution to the study of vascular plant distribution in western New York. It is not intended to be a field guide; no species descriptions or keys are included. The book appears to be well edited although some spelling errors were noted as well as five incorrect page numbers in the table of contents. The reasonable price should ensure wide use both in western New York and among those interested in the flora of the northcentral states.

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Vegetation of the Soviet Polar Deserts

By V. D. Aleksandrova (Translated by D. Löve). 1988. Cambridge University Press, New York. xxi + 228 pp., illus. U.S.$49.50.

This short monograph will be indispensable to all botanists, ecologists, and biogeographers doing research in the North American Arctic. In it, Dr. Vera Danilovna Aleksandrova, the Soviet Union's leading Arctic botanist, gives a summary of the work she has done, during a long and distinguished career, on the botany of the Soviet Arctic deserts.

Aleksandrova's definition of "arctic desert" is stringent. In Eurasia, only a tiny portion of mainland, the northernmost tip of the Taimyr Peninsula, is included. For the rest, palearctic deserts are confined to islands in the Arctic Ocean: the Franz Josef Archipelago, the Severnaya Zemlya Archipelago, and a few other small islands, together with the northeastern tip of Novaya Zemlaya, and Northeast Land (part of Svalbard). It is worth noting how little of the New World Arctic is desert as she defines it: narrow strips along the north coasts of Greenland and of Ellesmere and Axel Heiberg Islands; the whole of Ellef Ringnes, Borden, Mackenzie King, and Brock Islands; and bits of Amund Ringnes and Prince Patrick Islands.

The vegetation she describes is sparse and the flora poor. There are fewer than 60 vascular species, most of them circumpolar in range. Most of the relevés whose contents she lists are far richer in mosses and lichens than in vascular plants. But these few, small plants combine to form fascinating vegetation: "nanocomplexes" consisting of polygonal mosaics and networks of plants, on polygonally cracked soil. They are beautifully illustrated with unusually clear black-and-white photographs and well-drawn, uncluttered charts. Many elevation diagrams are given too, showing how roots and rhizoids are arranged in relation to each other and to soil cracks. Aleksandrova explains that the diameters of arctic desert polygons are only about half those of arctic tundra polygons. The vegetation pattern is therefore on a much smaller scale in desert than in tundra.

Canadian Arctic botanits who read the book will find it engrossing; they will want to compare the patterns described by Aleksandrova with those to be found in our Arctic, both in true polar desert and in the only slightly less austere conditions of far northern tundra. It should be noted, however, that this is a book for research workers, not for field naturalists in the ordinary sense. It is a scientific record of careful botanical exploration, carried out in some of the most arduous country on earth. The translation, by Doris Löve, is excellent; one is never conscious of the fact that it is a translation.

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ENVIRONMENT

Travel Diaries of a Naturalist, Volume 3: Japan, Indonesia, Hong Kong, China, Mongolia, the Philippines, Malaysia, Australia, New Zealand

By Peter Scott. Edited by M. Weston-Smith. 1987. Collins, Toronto. 223 pp., illus. $34.95.

In his last letter from the Antarctic, Captain Scott urged his wife to "Make the boy interested in natural history". The boy was his son Peter, then two years old. Now 79, this famous son of a famous father has more than fulfilled that last wish. An eminent artist, naturalist, and conservationist, he is now Chairman of the Wildfowl Trust in Great Britain.

This is the third volume of Peter Scott's travel diaries. They are not conventional chronological diaries, but rather accounts of travels in different groups of countries over several years, and the arrangement gives us a complete picture of an area and developments in it. This particular volume covers travels in the Far East from 1976 to 1981 including China, Japan, Mongolia, the Antipodes, Malaysia, Hong Kong, The Philippines, and Indonesia. [Volume I covered Africa, Antarctica, Australia and New Zealand, 1956-1979; and Volume II, Hawaii, Romania, Siberia, Iceland, Greenland and the United States 1956-1980.]

The text is written with a good deal of subtle humour, particularly about local politicians, and is quite uncomplaining about traveller's woes — cancelled flights, outdated visas, exotic foods (or no food at all), and the resulting stomach upsets. The journeys were undertaken on behalf of World Wildlife Fund (of which he was a founder and is now Honorary chairman of the International Council), the International Union for the Conservation of Nature (IUCN) of which he is Chairman of the Species Survival Commission, and several other international organizations. Some of the journeys were made as resident naturalist on Lindblad Explorer tours.

In spite of heavy official schedules, the author managed to spend time in the field. He particularly enjoys fish-watching by scuba diving and he is enthusiastic about butterflies, flowers, and mammals. He even comments on wildlife and plants along roads to airports. A measure of his lifelong interest in waterfowl comes towards the end of China section. After many years of searching, he finally saw some Chinese mergansers (*Mergus squamatus*). This left only one species of waterfowl he had not yet seen alive: the Brazilian merganser! However, Peter Scott is far from being exclusively a bird watcher.

The diaries reveal how prominent "naturalist ambassadors" persuade kings, princes, and governments to join world organizations such as World Wildlife Fund (WWF), and ratify international conservation agreements such as CITES and the International Whaling Commission treaties. There are some interesting entries about the WWF project in Wolong Reserve, China to set up the Giant Panda breeding station. It took some diplomacy to obtain permission for George Schaller to carry out the basic field research on the wild population.

The wide margins allow for a profusion of paintings and drawings of species seen on the diary day — there are so many that the book could be used as an auxiliary field guide for the more remote areas of the world. This volume can stand by itself as a unique, interesting, and handsomely illustrated book. All three volumes are a feast for anyone interested in the global effort for conservation, and for the preservation of species.

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The Maine Woods

By Henry David Thoreau, with introduction by Edward Hoagland. 1988. Reprint of 1864 edition. Penguin Nature Library, Penguin Books, Markham, Ontario. xxxiii + 442 pp. $10.95.

Good nature writing is a complex amalgam of art and science, fact and feeling, dispassionate observation and personal interpretation. Great nature writing transcends the boundaries of classification, being first and foremost great literature. The writings of Henry David Thoreau have endured for these reasons. As the author of such acknowledged masterpieces as *Walden* and *On Civil Disobedience*, Thoreau left a literary legacy that has influenced millions, including such disparate luminaries as Leo Tolstoy and Mahatma Gahdhi. As Edward Hoagland states in the introductory pages of this edition, ". . . Thoreau made of the close observation of bits of nature a lever to examine life in many ways on a large scale. Yet nature writing, despite its basis in science, usually rings with rhapsody as well . . . One reads Thoreau for his foxy grace and crystalline precision, his joyful inventories and resilient spirits." To the naturalist, Thoreau's keen perceptions of the natural world are the principal delight of his writings, a recurring theme against which his ideas and philosophies are played in counterpoint.

The Maine Woods chronicles three expeditions Thoreau made into the hinterlands of the American northeast: the first in 1846 (while his residence was still on the shores of Walden pond) to the summit of Mount Katahdin; the second in 1853 by steamer, wagon, and canoe to the head of Chesuncook Lake and beyond, and the third, in 1857, to the Allegash and East Branch, in the wilds near the Canadian border. Though parts were published in two magazines during Thoreau's lifetime, these accounts did not appear in book form until 1864, two years after his death.

The present volume encompasses all three narratives (*Ktaadn, Chesuncook,* and *The Allegash and East Branch*), preceeded by an interesting 33-page Introduction by editor Hoagland. A seven-section Appendix by Thoreau concludes the text. The volume includes a fairly comprehensive general index. The anachronistic style of indexing and the disparity in typeface between Hoagland's 1988 Introduction and the rest of the book seem to indicate that it is a direct reproduction of an earlier edition, but it is unclear whether or not the original 1864 publication by Ticknor and Fields was used as the source. The 13 × 20 cm paperback is unillustrated save for the front cover, which bears a photograph of the author's stiffly-posed, rather rumpled countenance superimposed over a background of maple trees.

The Maine Woods is in many regards a "conventional" travel book outlining points of interest, travel itineraries, conveyances used, guides engaged, and equipment procured. Yet, even these commonplaces provide a fascinating glimpse into the realities of backwoods travel in the mid-19th century. (In spite of his disdain for Yankee pragmatism, Thoreau went as far as to include, in the appendix, a detailed list of accouterments for a twelve-day long excursion into the Maine woods — including such essentials as sixteen pounds of pork "in an open keg, sawed to fit", twelve pounds of sugar, a check shirt, one pair drawers, a neck ribbon, two bosoms and collars "to go and come with", three or four old newspapers, much twine, a pint of salt, six lemons "good to correct the pork and warm water", one quart Indian meal, plant-book and red blotting-paper, small pocket spy-glass for birds, pocket-microscope, tape measure, and insect-boxes). All three accounts burst with Thoreau's characteristic wealth of detailed observation, from depictions of the woods, the logging camps, the Indian villages and the woodsman's way of life, to carefully-crafted descriptions of the rainbow flash of trout for the frying pan and other minutinae of the campfire breakfast menu. Thoreau the naturalist is evident in the meticulous lists of plants, birds, and terrestrial fauna interspersed throughout the text and collated in the appendix. Thoreau the anthropologist provides accounts of the twilight days of the native Abnakis, forever changed by contact with the whites, and includes a brief glossary of common Abnaki words and phrases gleaned from Indian guides and acquaintances. And Thoreau the transcendentalist philosopher is everywhere in evidence; insightful pronouncements on the rapid despoilation of the American wilderness and on the isolation of man (native *and* white) from the natural environment echo many of the themes found in *Walden*, and elevate this book far above the rank of other 19th-century travelogues.

Yet *The Maine Woods* remains an absorbing, convivial, often buoyant chronicle of the natural history, native culture, and settling of the American northeast, as well as an entertaining and informative guide to roughing it, 19th-century style. Though perhaps less profound than *Walden,* the *Journal,* or the important expository essays, it adds flesh and substance to the popular caricature of "Thoreau-by-the-pond", and provides further opportunity for contemplating the thoughts of one of the most important natural philosophers of the New World.

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Churchill: Polar Bear Capital of the World

By Mark Fleming. 1988. Hyperion Press, Winnipeg. 94 pp., illus. $25.00.

Each year, particularly during the brief summer period, thousands of southerners flock to Churchill, Manitoba — a small dot of civilization set against endless reaches of muskeg on one side, and desolate Hudson Bay on the other. Arriving by commercial jet service or the slow train that creeps hesitantly over tracks built over permafrost or soggy ground, visitors excitedly pursue their special interests for a few days or weeks. The author, Mark Fleming, supported by over 100 color photographs from many sources, attempts to uncover the magic of this place, whose fascinating history stretches back 4000 years of Native presence, and 400 years of European-Canadian contact. Churchill's past is highlighted with Fort Prince of Wales, the Hudson's Bay Company, construction of the railroad, the grain-handling sea port, the Canada-United States military base, the Rocket Range, the Eskimo Museum, the Town Complex, and other features. Touched on briefly are the exploits and contributions of past and present citizens — Inuit hunters, explorers like Samuel Hearne, the clergy, entrepreneurs, artists, government officials, and many others who have called this town home. An indomitable civil spirit overcomes the isolation, typified by celebrating Canada Day with a beach party, complete with cut-out palm trees, wind-surfing, and swim races to and back from the nearest iceberg in the bay. This souvenir book is sufficient to lure any adventurous soul to experience the North, albeit with modern conveniences nearby.

Naturalists stream to Churchill for the rich mix of boreal, tundra, and marine plants and animals, many of which reach their distributional limits in this region. Bird-watchers are delighted with new species (such as Ross's Gull and Willow Ptarmigan) for their life lists, belugas and seals are only a harbor boat ride away, while in the autumn, tundra buggies filled with tourists track down Polar Bears in the frozen wastes. Many other people come in search of the dwarf but magnificent flowers and unusual tundra plants that splash the countryside with color. No photographer can resist the brilliant sunsets, dancing aurora, gray bedrock of Churchill quartzite polished smooth by glaciers and waves, and the massive white icebergs sculpted into fantastic shapes and left stranded along the shore by five-metre-high tides. These powerful images of northern life and environment jump from the pages and stimulate one to contemplate travel plans.

The photography is of good quality and depicts a wide range of subject matter to interest naturalists. The design is attractive, without stamp-sized pictures often flawing other such books. Through his captions and choice of anecdotes, Fleming reveals that he too has fallen under the spell of Churchill's history, townspeople, wildlife, and scenery. Whether or not your feet have tread the gravel streets of Churchill, I think you will enjoy this book.

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Advances in Marine Biology, Volume 23

Edited by J. H. S. Blaxter and A. J. Southward. 1988. Academic Press (Canadian distributer, Harcourt Brace Jovanovich, Toronto). xi + 385 pp., illus. $117.95.

Advances in Marine Biology is a yearly publication for those that have training or a working knowledge in this field of study. The papers published tend to be highly technical. The three papers in this volume are no exception.

The first paper is written by A. R. O. Chapman and is entitled "Population and Community of Seaweeds". Dr. Chapman provides the reader with a lengthy and detailed literature review of seaweed ecology. The literature cited begins in 1928 and ends with 1983. The bulk of literature cited occurs in the last ten years. The paper is well organized and complete, in my opinion, including a complete bibliography. Of particular interest to me is the discussion dealing with the use of multivariant analysis as applied to seaweed communities.

The second paper was written by J. Le Fèvre and is entitled "Aspects of the Biology of Frontal Systems". The focus of the paper is on the northwest European continental shelf with particular emphasis on tidal and shelf-break fronts. The object of the paper is to raise questions for further research in the area. I feel this objective is achieved. The discussion includes both physical and biological aspects of frontal formation. Dr. Le Fèvre, throughout the paper, points out areas of study requiring further investigation.

The third paper was written by J. Frederick Grassle and is entitled "The Ecology of Hydrothermal Vent Communities". The paper is a discussion of the ecology of the relatively recent discovery of unique ecosystems found in the vicinity of hydrothermal vents. Dr. Grassle provides a description of the physical and biological aspects. The paper is brief compared to the other papers but not incomplete. The brevity is more a reflection of the limited data available in regards to this new area of study. The reader is provided with a detailed description of hydrothermal vent ecosystems and a reference list for further individual study.

Advances in Marine Biology, Volume 23 provides the trained marine biologist with three papers dealing with seaweed ecology, biology of frontal systems, and the ecology of hydrothermal vent communities. The papers are technical in nature and therefore would be difficult for someone without some acquaintance with technical training to read.

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Northern Prairie Wetlands

Edited by Arnold van der Valk. 1989. Iowa State Univerity Press, Ames. xiv + 400 pp., illus.

In the heart of the continent, one of our most wonderful, distinctive, and abused landscapes is slowly disappearing, not because of global warming, though that might become a reality, but because of crass social neglect. Prairie wetlands, almost by definition, are precarious. They exist in a highly continental climate, with hot dry summers, frigid winters, and water-table conditions that oscillate ominously as the seasonal extremes vary. But they form an ecosystem that is at once unique in its beauty, particular in its array of environments, plants, and fauna, and irresistible to the growing pressures from agriculture, hunting, and ill-conceived development.

Prairie naturalists on both sides of the international border know and cherish their wetland environments. The Northern Prairie Wildlife Center in North Dakota, and the Delta Waterfowl and Wetlands Research Station in Manitoba have been significant focal points for research into the ecology of these systems. The entire community of naturalists and scientists who have been influenced, directly and indirectly, by the northern prairie wetlands and these research centres, will welcome this fine book, which brings together in a readable, clear and well-illustrated format, our current understanding of the ecology of these threatened parts of our natural heritage. Appropriately, the book is dedicated to four of the leading experts on the subject — J. Henry Sather, Jennifer Walker-Shay, Peter Ward, and Milton Weller.

The 400 pages of text, illustrations, and index provide the naturalist and professional ecologist with an authoritative, well organized, balanced review of all relevant aspects of the subject. The urgency of the problem is set out in the first chapter, on the political and economic aspects, and the message is explicit — "We do not need to spend much more time plotting the course of a sinking ship; we need to stop it from sinking." Some of us know at first hand, that the effects of continued drainage of prairie wetlands, exacerbated in dry years with or without "greenhouse effect" signatures, enables us to literally drive a vehicle over areas that less than a decade ago were marshes and shallow lakes. This opening chapter sharpens our wits to analyse carefully what follows — three chapters, on hydrology, water chemistry, and runoff from farming fertilizers, and while we learn much about the basic interactions that occur between water table, soil, and wetlands, the clear message is that our state of knowledge is woefully inadequate.

A big, central chapter on flora and vegetation is an excellent conflation of a dispersed, variable literature, and it will take its place as the definitive summation of the subject for several years. Floristic, dynamic, and phytosociological aspects get full play, but detailed consideration of the effects of fire, grazing, drainage, and other factors make this a key section of the book.

The latter half of the book consists of expertly compiled accounts of algae, ducks, waterfowl habitats, mammals, fishes, and energetics of wetland ecosystems, with a concluding chapter on the unusual wetlands of the Nebraska Sandhills. A fifteen page index provides full coverage of topics, tables, and taxonomic names.

Professor A. van der Valk, the general editor, and his co-authors have succeeded admirably in transforming what began as a symposium, held five years ago, into a major text that will find an important place in the libraries of naturalists, students, and professional ecologists of all stripes and institutional affiliations. The price is reasonable. The text is clean. The illustrations are appropriate.

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Life in the Cold: An Introduction to Winter Ecology

By Peter J. Marchand. 1987. University Press of New England, Hanover, New Hampshire. xiv + 176 pp., illus. Cloth U.S.$18.00; paper U.S.$9.95.

Life in the Cold is not an evening's light reading as may be alluded to by the title. The author, Peter Marchand, is a university professor who has devoted his last 15 years to the teaching of winter ecology. He has obviously written this book with his senior undergraduate and graduate students in mind. This book is an introduction only in that it covers a very limited scope of winter ecology, but due to the technical jargon scattered throughout, it is not an ideal introductory reference for the lay naturalist. In the preface, the author admits that "Despite my best attempts at simplification, it will be awkwardly clear in places that my primary commitment is still to the science rather than the prose."

The book is divided into seven chapters which deal primarily with the physics of snow and ice; plant and animal adaptations to cold, snow, and ice; and the physiological and behavioural adaptations of animals including humans to winter. The emphasis has been placed on physics and plant physiology.

There is a five-page glossary of technical terms (which partially alleviates the problem of scientific jargon) as well as an index of the plants, animals, and scientific concepts mentioned in the text. The author has also inserted a ten-page section entitled "Notes" which actually contains only one note, the remaining 146 entries are references cited in the text. The casual reader might find that there are more than sufficient references cited in the text. However, a senior university student will find that certain sections of the text could use additional referencing.

Through physics and physiology, the author explains numerous phenomena which most field naturalists would find insightful, including how snow metamorphoses in snow shelters, how ice fog develops, why the coldest period of the winter does not coincide with the shortest days of the year, how photosynthesis in aspen bark enhances the tree's survival, why white pelage of arctic mammals provides greater insulation than dark pelage, why birds shiver, or why hares feed selectively on mature shrub stems rather than on young saplings in winter.

The text is generally accurate and concise but I did note a couple of confusing figures. Figure 2.5 is a photo which supposedly illustrates snow loading on conifers, in reality it depicts the build up of kanik or hoar frost. In Figure 27, two graphs were presented which depicted similar sets of data with no explanation. Either one of the graphs would have been less confusing and adequate to illustrate the concept being discussed.

The areas obviously deficient from this introductory text on winter ecology include permafrost formation and distribution, the influence of permafrost on plants and animals, hypothermia in humans, and human cultural adaptations to cold, among others.

In conclusion, if the reader is willing and able to wade through the scientific jargon, s/he may be rewarded with some fascinating glimpses into the winter world.

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NEW TITLES

Zoology

***Acta XIX Congressus Internationalis Ornithologici, Volumes 1 and 2, 22-29 June, 1986, Ottawa.** 1988. Edited by Henri Ouellet. University of Ottawa Press, Ottawa. 2815 pp. $175 plus postage, 5% in Canada, 10% elsewhere.

***Analysis in behavioral ecology: a manual for lab and field.** 1988. By Luther Brown, George Mason, and Jerry F. Downhower. Sinauer, Sunderland, Massachusetts. 194 pp., illus. U.S.$13.95.

Animal behavior: an evolutionary approach. 1988. By John Alcock. Fourth edition. Sinauer, Sunderland, Massachusetts. 652 pp., illus. U.S.$34.95.

***Animal navigation.** 1989. By Talbot H. Waterman. Freeman (Distributed by Oxford University Press, Don Mills, Ontario). 256 pp., illus. $49.95.

Birds of Calgary. 1988. by Robin B. Bovey. Lone Pine, Edmonton. $9.95.

Birds of Edmonton. 1988. By Robin B. Bovey. Lone Pine, Edmonton. $9.95.

***Birds to watch: the ICBP world checklist of threatened birds.** 1989. By Nigel J. Collar and Paul Andrew. Smithsonian Institute Press, Washington. xv + 304 pp. U.S.$18.95.

The compact guide to birds of the Rockies. 1988. By Geoffrey L. Holroyd. Lone Pine, Edmonton. $9.95.

***Encyclopedia of paleoherpetology, part 17c: Anomodontia.** 1988. By Gillian M. King. Gustav Fischer Verlag (Distributed by VCH, Deerfield Beach, Florida). xii + 174 pp., illus. U.S.$147.

***Étude et amenagement de la frayère multispecifique de la Rivière aux Pins et dynamique de la population de grand brochet, *Esox lucius* L., du Fleuve Saint-Laurent, Boucherville, Quebec.** 1988. Par Gerard Masse, Rejean Fortin, Pierre Dumont, et Jocelyne Ferraris. Québec Ministère du Loisir, de la Chasse, et de la Pêche, Montréal. xxvii + 224 pp., illus.

***The Facts on File field guide to north Atlantic shorebirds: a photographic guide to the waders of eastern North America and western Europe.** 1989. By R. J. Chandler. Facts on File, New York. 192 pp., illus. U.S.$19.95; $25.95 in Canada.

***A field guide to the birds of Mexico.** 1989. By Ernest P. Edwards. Second edition. E. P. Edwards, Sweet Briar, Virginia. x + 118 pp., illus. Cloth U.S.$23.50; paper U.S.$19.50.

***Life of the tanager.** 1989. By Alexander F. Skutch. Cornell University Press, Ithaca. xii + 111 pp., illus. + 24 plates. U.S.$36.50.

***On the track of ice age mammals.** 1986. By Anthony J. Sutcliffe. Harvard University Press, Cambridge, Massachusetts. 224 pp., illus. Cloth U.S.$25; paper U.S.$12.95.

***Polar bears.** 1988. By Ian Stirling. University of Michigan Press (Canadian distributor: Fitzhenry and Whiteside, Markham, Ontario. x + 220 pp., illus. $55.

***The trout and salmon handbook.** 1989. By Robin Ade. Facts on File, New York. 122 pp., illus. U.S.$19.95; $25.95 in Canada.

†Whales of the world. 1989. By Nigel Bonner. Facts on File, New York. 192 pp., illus. U.S.$22.95; $30.95 in Canada.

***Who eats whom.** 1989. Edited by Pierre Pfeffer. Facts on File, New York. 480 pp., illus. U.S.$50; $65 in Canada.

***World birdbase (TM).** 1988. By Santa Barbara Software Products, Santa Barbara, California. Computer Program, 640 k, 3 disk + 76 pp. manual. U.S.$99 + U.S.$5 shipping.

Botany

***The biology of polar bryophytes and lichens.** 1988. By R. E. Longton. Cambridge University Press, New York. viii + 391 pp. U.S.$95.

†Botanical exploration of the Canadian watershed of Lake Huron during the nineteenth century. 1989. By James S. Pringle. Canadian Horticulture History volume 2, numbers 1 & 2. Royal Botanical Gardens, Hamilton. 88 pp., illus. $7.

Chinese bamboos. 1988. By Chen Shou-Liang and Chia Liang-Chi. Timber Press, Portland, Oregon. 118 pp., illus. U.S.$39.95.

Edible garden weeds of Canada. 1988. By Adam F. Szczawinski and Nancy J. Turner. Reissue of 1978 edition. Fitzhenry and Whiteside, Markham, Ontario. 184 pp., illus. $16.95.

Edible wild fruits and nuts of Canada. 1988. By Nancy Turner and Adam F. Szczawinski. Reissue of 1979 edition. Fitzhenry and Whiteside, Markham, Ontario. 212 pp., illus. $16.95.

†Evaluation biologique de la baie située au sud de l'Ile Saint-Marie, Carignan, MRC la Vallée-du-Richelieu et Saint-Luc, MRC le Haut-Richelieu. 1988. Par Jean Dubé, Jocelyne Brisebois, et Louis-Marc Soyez. Rapport de travaux 06-03. Québec Ministère du Loisir, de la Chasse, et de la Pêche, Montréal. xi + 85 pp., illus. + annexe photographique.

†Flora of the north shore of Lake Superior (vascular plants of the Ontario portion of the Lake Superior drainage basin). 1989. By James H. Soper, Claude E. Garton, and David R. Given. Syllogeus 63, National Museum of Natural Sciences, Ottawa. 61 pp. $3.95 plus $2.50 shipping ($5 shipping outside of Canada).

Floristic inventory of tropical countries: the status of plant systematics, collections, and vegetation, plus recommendations for the future. 1989. Edited by David G. Campbell and H. David Hammon. New York Botanical Garden, Bronx. 550 pp., illus. U.S.$80.55 in U.S.A.; U.S.$91.40 elsewhere.

†Les forêts du parc national de la Mauricie, au Québec. 1989. Par Richard Lalumière et Michel Thibault. Les Presses de l'Université Laval, Québec. xvii + 495 pp., illus. + 3 cartes. $55.

***The genus *Cyclamen*.** 1988. By Christopher Grey-Wilson. Timber Press, Portland, Oregon. 148 pp., illus. U.S.$28.95.

The genus *Cymbidium*. 1988. By David Du Puy and Phillip Cribb. Timber Press, Portland, Oregon. 264 pp., illus. U.S.$59.95.

The genus *Pleione*. 1988. By Phillip Cribb, Ian Butterfield, and C. Z. Tang. Timber Press, Portland, Oregon. 128 pp., illus. U.S.$32.95.

***The genus *Vaccinium* in North America.** 1989. By S. P. Vander Kloet. Agriculture Canada (Canadian Government Publishing Centre, Ottawa). 203 pp., illus. $46.50 in Canada; $55.80 elsewhere plus $2.25 shipping.

Grasses of western India. 1989. By Toby and Patricia Hodd. Second edition. Oxford University Press, Don Mills, Ontario. 174 pp., illus. $11.95.

A guide to the wild orchids of Great Britain and Ireland. 1989. By David Lang. New edition. Oxford University Press, Don Mills, Ontario. 240 pp., illus. $20.95.

A habitat field guide to trees and shrubs of Alberta. 1988. By Kathleen Wilkinson. Lone Pine, Edmonton. $19.95.

Hebes and parahebes. 1988. By Douglas Chalk. Tiber Press, Portland, Oregon. 160 pp., illus. U.S.$32.95.

A manual of saxifrages. 1988. By D. A. Webb and R. J. Gornall. Timber Press, Portland, Oregon. 320 pp., illus. U.S.$57.95.

Natioal list of plant species that occur in wetlands: national summary. 1988. By the U.S. Fish and Wildlife Service. U.S. Government Printing Office, Washington. 250 pp. U.S.$12.

***A photographic field guide to mosses, lichens, and ferns of northwest North America.** 1988. By Dale Vitt, Janet Marsh, and Robin Bovey. Department of Botany, University of Alberta, Edmonton. $24.95.

***Plants of Riding Mountain National Park, Manitoba.** 1989. By William J. Cody. Canadian Government Publishing Centre, Ottawa. Illus. $24.75 in Canada; U.S.$29.70 elsewhere plus $1.90 shipping.

***Weeds and words: the etymology of scientific names of weeds and crops.** 1989. By Robert L. Zimdahl. Iowa State University Press, Ames. xix + 125 pp. U.S.$19.95 plus U.S.$2 postage.

Wildflowers of the western Cascades. 1988. By R. A. Ross and H. L. Chambers. Timber Press, Portland, Oregon. 140 pp., illus.

Environment

***Birds and berries.** 1988. By Barbara and David Snow. Buteo Books, Vermillion, South Dakota. 268 pp., illus. U.S.$37.50.

Development in coastal and estuarine pollution. 1988. Edited by W. R. Parker. Proceedings of a conference, Fukuoka, Japan, 18-21 October, 1987. Pergamon Press, Elmsford, New York. 300 pp., illus. U.S.$112.

***Ecology and our endangered life-support system.** 1988. By Eugene P. Odum. Sinauer, Sunderland, Massachusetts. 212 pp., illus. U.S.$14.95.

†**The ecology of Australia's wet tropics.** 1988. Edited by R. Kitching. Proceedings of the Ecological Society of Australia Volume 15. Surrey Beatty, Chipping Norton, Australia. v + 326 pp., illus. U.S.$53.

Everglades wildguide: the natural history of Everglades National Park, Florida. 1988. Author unlisted. U.S. Government Printing Office, Washington. 103 pp., illus. U.S.$5.50 + 25% foreign surcharge.

Life at the edge. 1989. Edited by James L. and Carol Grant Gould. Freeman (Distributed by Oxford University Press, Don Mills, Ontario). 192 pp., illus. $14.95.

Marine planktology. 1988. By Z. Zheng. Springer-Verlag, New York. c500 pp. cU.S.$96.50.

†**Mathematical modeling in ecology: a workbook for students.** 1988. By Clark Jefferies. Birkhauser Verlag, Therwil, Switzerland. x + 193 pp., illus. SFr 49.50.

***A neotropical companion: an introduction to the animals, plants, and ecosystems of the new world tropics.** 1989. By John C. Kricher. Princeton University Press, Princeton. xii + 434 pp., illus. Cloth U.S.$45; paper U.S.$16.95.

†**The risk assessment of environmental hazards: a textbook of case studies.** 1989. Edited by Dennis J. Paustenbach. Wiley, New York. 1184 pp. U.S.$125.

A sand county almanac and sketches here and there. 1989. By Aldo Leopold. Commemorative edition. Oxford University Press, Don Mills, Ontario. 272 pp., illus. $11.95.

Seeking consensus: the public's role in environmental decision making. 1988. By The Canadian Society of Environmental Biologists. Edmonton. Proceedings of a conference. $12.

Size-structured populations: ecology and evolution. 1988. Edited by B. E. Ebenman and L. Persson. Springer-Verlag, New York. c310 pp. cU.S.$84.50.

***State of Washington Natural Heritage Plan.** 1989. By the Department of Natural Resources, Olympia, Washington. viii + 167 pp., illus.

†**Those of the forest.** 1989. By Wallace Byron Grange. Reissue of 1953 edition. Willow Creek Press, Wautoma, Wisconsin. 330 pp., illus. U.S.$19.50 + U.S.$2 shipping.

Toxic water pollution in Canada: regulatory principles for reduction and elimination with emphasis on Canadian federal and Ontario law. 1989. By P. Muldoon and M. Valiante. Canadian Institute for Resources Law, Calgary. 120 pp. $22.

The value of conserving genetic resources. 1988. By Margery L. Oldfield. Sinauer, Sunderland, Massachusetts. 388 pp., illus. Cloth U.S.$40; paper U.S.$19.95.

Miscellaneous

***The field naturalist: John Macoun, the Geological Survey, and natural science.** 1989. By W. A. Waiser. University of Toronto Press, Toronto. xxxiv + 253 pp., illus. $30.

Four billion years: an essay on the evolution of genes and organisms. 1988. By William F. Loomis. Sinauer, Sunderland, Massachusetts. 286 pp., illus. Cloth U.S.$39.95; paper U.S.$22.95.

†**Free: the end of the human condition: the biological reason why humans have had to be individual, competitive, egocentric, and aggressive.** 1988. By Jeremy Griffith. Centre for Humanity's Adulthood, Sydney, Australia. 228 pp., illus.

Speciation and its consequences. 1989. Edited by Daniel Otte and John A. Endler. Sinauer, Sunderland, Massachusetts. 672 pp., illus. Cloth U.S.$50; paper U.S.$29.95.

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